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with

Ceramic Abstracts

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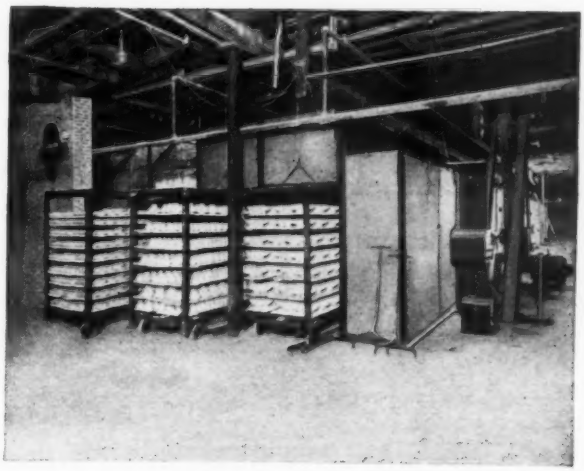

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JOURNAL
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A monthly Journal devoted to the arts and sciences related to the silicate industries.

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Vol. 5 **April, 1922** **No. 4**

EDITORIALS

THE CHEMISTRY AND PHYSICS OF HIGH TEMPERATURES

The importance of the economical production and exact control of high temperatures to the industrial life of a nation can scarcely be over-emphasized. An English writer has recently gone so far as to state that "the future industrial success of any country will largely depend upon the extent to which it develops high temperature processes." The interest of the ceramic profession in this subject is two-fold. In the first place it has a primary interest arising from the fact that practically all of the ceramic industries belong themselves to the class of high temperature industries and all matters relating to the economical production and control of high temperature are therefore of paramount importance to the profession. In the second place all high temperature industries are dependent upon the ceramic profession for their supplies of that *sine qua non* of high temperature processes, refractory materials.

It is, therefore, not sufficient that the ceramic engineer be thoroughly conversant with the chemistry and physics of the manufacture of refractory materials. If he is to be of the greatest assistance to the high temperature industries which he serves,

he must be familiar also with the chemistry of these industries because the refractories which he undertakes to produce must be capable not only of withstanding high temperatures alone but capable also of withstanding a variety of chemical influences. Moreover, the refractory must not introduce harmful materials into the manufactured products. The ceramic profession has therefore a vital interest in the whole field of high temperature research.

Among the non-ceramic industries which employ high temperatures may be mentioned the coke industry with its numerous by-products, the gas industry, the fixed nitrogen industries, the electric furnace industries and nearly all of the metallurgical industries. High temperature chemistry and physics is thus far-reaching in its importance to modern civilization and is an attractive field for the investigator. Perhaps some millionaire (?) brick manufacturer will sometime wish to establish a permanent memorial by founding and endowing an institute for research in the chemistry and physics of high temperatures. Such an institution would be a great boon to all industries having high temperature problems to meet.

1922 CONVENTION A RECORD

The 24th Annual Convention held February 27 to March 3, inclusive, at St. Louis, Missouri, was a record breaker in more than one respect. The attendance was 417, registered; original papers on the program were 164, aside from the 22 which were listed as having been previously published and to be discussed; the entertainment furnished by the local committee was replete with novel and highly pleasing numbers; the meetings of the seven Divisions and those of the general sessions were conducted on schedule and with a smoothness that was unusual, and harmony and singleness of purpose was in every heart, mind and act. Too much praise can not be given to the local committee for their superb management.

By divisions the attendance was as follows: Art Division, 25; Enamel Division, 87; Glass Division, 55; Heavy Clay Products Division, 67; Refractories Division, 82; Terra Cotta Division, 33; White Wares Division, 65; making a total of 414.

Officers elected for the year 1922:

Frank H. Riddle, *President*
E. Ward Tillotson, *Vice-President*
R. K. Hursh, *Treasurer*
B. E. Salisbury, *Trustee*

The other members of the Board are R. H. Minton, F. K. Pence, F. B. Ortman, R. M. Howe.

ORIGINAL PAPERS AND DISCUSSIONS

THE INFLUENCE OF GRIND AND BURN ON THE CHARACTERISTICS OF SILICA BRICK[1]

By R. M. Howe and W. R. Kerr[2]

ABSTRACT

Finer grinding improves the appearance of the brick and increases their strength somewhat but not in any marked degree, within the commercial limits of grinding. A grinding of from 15 to 20 minutes seems most desirable. The time of grinding does not affect the porosity appreciably. The firing temperature is the principal factor governing the final strength and also the permanent residual expansion. The maximum temperature cone 19, yielded the highest strength and the lowest expansion.

An earlier investigation showed that 17 standard brands of commercial silica brick possessed moduli of rupture varying from 401 to 921 pounds per square inch. Certain of these brick were made to meet special conditions where high strength was unnecessary. In other cases the variation between brands was entirely due to different manufacturing conditions. The present investigation was instigated to determine the effect of two very important steps in the process of manufacture—grinding and burning.

The samples used in this investigation were made by taking mud from the same batch after grinding for 10, 15 and 20 minutes. Samples of each grind were burned at each of six temperatures ranging from cone 11 to cone 19.

McDowell[3] has already reported the results of a similar investiga-

[1] Received Jan. 30, 1922.

[2] Fellows, Refractories Manufacturers' Association Fellowship 5, Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

[3] "A Study of the Silica Refractories," G. S. McDowell, *Bull. Am. Inst. Mining Eng.*, **1916**, 2019.

tion, although the same procedure was not involved. Instead of burning different samples from cones 11 to 19 he burned the same samples one, two, or three times at cone 14 or 15. He reported that "the fine grind shows little if any advantage over the regular grind," "there is an advantage in burning the brick a second time," and "it is probable that stronger brick would be produced by maintaining the maximum temperature a greater length of time during a single burn than by resorting to repeated burning."

The effect of time upon the grind of the mud is shown by Table I.

TABLE I—SCREEN ANALYSES OF SILICA MUD AFTER 10, 15 AND 20 MINUTE GRINDS

Time of grind in minutes	10	15	20
Remaining on 10 mesh	17.8%	10.0%	3.0%
Remaining on 20 mesh	6.0%	8.0%	7.6%
Remaining on 40 mesh	10.7%	11.5%	12.5%
Remaining on 60 mesh	17.2%	19.0%	18.5%
Remaining on 80 mesh	12.0%	12.7%	13.0%
Remaining on 100 mesh	5.0%	5.2%	6.0%
Remaining on 120 mesh	3.8%	5.0%	4.8%
Remaining on 140 mesh	.5%	.5%	.5%
Passing through 140 mesh	27.0%	28.1%	34.1%

The effect of the grind and burn upon the modulus of rupture is shown in Table II. Each of the figures in columns 2, 3 and 4

TABLE II—INFLUENCE OF GRIND AND BURN UPON THE MODULUS OF RUPTURE OF SILICA BRICK

Temperature of burn in cones	Time of grind in minutes 10	15	20	Average modulus of rupture for all grinds at each cone
11	295	285	330	303
14–15	324	400	381	368
16–17	436	372	523	444
17	526	605	585	572
18	525	513	581	533
19	531	618	694	514
Average modulus of rupture for each grind at all cones	440	446	499	

represents an average of at least seven observations. The figures in the fifth column represent the average strengths of 21 brick of 3 grinds burned at the indicated temperature. The fig-

ures in the bottom row of this table (II) represent the average strengths of 42 samples of each grind burned at 6 different temperatures. Consequently these last two sets of figures are particularly significant.

Table III and IV are compiled in the same way as Table II.

TABLE III—INFLUENCE OF GRIND AND BURN UPON THE SPECIFIC GRAVITY OF SILICA BRICK

Temperature of burn in cones	Time of grind in minutes 10	15	20	Average specific gravity for all grinds at each cone
11	2.49	2.52	2.50	2.50
14–15	2.38	2.39	2.38	2.38
16–17	2.36	2.35	2.36	2.36
17	2.33	2.33	2.33	2.33
18	2.31	2.31	2.32	2.31
19	2.30	2.31	2.30	2.30
Average specific gravity for each grind at all cones	2.362	2.368	2.365	....

They refer to the porosity and specific gravity of the various samples.

Tables V and VI combine the average results expressed in Tables

TABLE IV—INFLUENCE OF GRIND AND BURN UPON THE POROSITY OF SILICA BRICK

Temperature of burn in cones	Time of grind in minutes 10	15	20	Average porosity for all grinds at each cone
11	27.15	28.46	28.13	27.91
14–15	27.27	28.19	29.45	28.30
16–17	26.68	28.40	29.08	28.05
17	26.90	26.95	30.40	23.08
18	25.15	26.78	28.23	26.72
19	28.00	27.80	26.96	27.59
Average porosity for each grind at all cones	26.86	27.76	28.71	.....

TABLE V—INFLUENCE OF GRIND UPON SEVERAL CHARACTERISTICS OF SILICA BRICK

Time of grind in minutes	Average value for all burns and one grind: Specific gravity	Residual permanent expansion	Modulus of rupture	Per cent porosity
10	2.362	1.5%	440	26.86
15	2.368	1.6%	4:6	27.76
20	2.365	1.6%	499	28.71

II, III, and IV. Each of the values in Tables V and VI therefore represents the average of from 21 to 42 observations. The permanent expansion remaining in the brick has been calculated from the tables of F. A. Harvey and E. N. McGee[1] and these values are also included.

Table V shows conclusively that the time of grinding Medina Quartzite may be varied 100 per cent without seriously changing the strength of the bricks. The texture, to be sure, varied to the degree shown in Table I and this characteristic affected the workmanship somewhat. Generally speaking, the bricks of the finer grinds had better appearances. The modulus of rupture, however, varied only 14 per cent, the porosity 2 per cent, and the expansion practically none. These conclusions are deduced from this table in preference to the others because each figure represents so many observations.

TABLE VI—INFLUENCE OF BURN UPON SEVERAL CHARACTERISTICS OF SILICA BRICK

	Average value for all grinds at each cone			
Temperature of burn in cones	Specific gravity	Residual permanent expansion	Modulus of rupture	Per cent porosity
11	2.50	4.2%	303	27.91
14–15	2.38	2.0%	358	28.30
16–17	2.35	1.3%	444	28.05
17	2.33	.8%	572	28.08
18	2.31	.4%	533	26.72
19	2.30	.2%	614	27.59

Table VI, however, shows that the burning temperature exerts a tremendous influence upon the characteristics of the finished brick. The porosity was not affected by the burning temperature but the expansion and strength varied more than 100 per cent over a range of 6 cones.

A second lot of brick was made from similar quartzite and the general method of procedure was the same. The grinds included 6, 13, and 20 minute periods and therefore covered a broader range. The burns were restricted to one at cone 14–15, one at cone 17, and one at cone 19. The screen analyses of the mud

[1] "Testing Coke Oven Refractories," Harvey and McGee, *This Jour.*, **4**, 475 (1921).

and the average physical characteristics of the brick are given in Tables VII and VIII. The results of the tests made upon the

TABLE VII—EFFECT OF GRIND UPON MUD AND BRICK OF SERIES II

Time of grind in minutes		6	13	20
Per cent mud on 10 mesh		29.7	19.5	13.0
Per cent mud on 20 mesh		3.7	4.0	4.0
Per cent mud on 40 mesh		7.5	7.3	7.1
Per cent mud on 60 mesh		16.8	19.8	21.3
Per cent mud on 80 mesh		12.4	14.4	15.7
Per cent mud on 100 mesh		5.0	5.6	5.8
Per cent mud on 120 mesh		3.3	4.0	3.0
Per cent mud on 140 mesh		.3	.3	.3
Per cent through 140 mesh		21.3	25.1	28.6
Average values for brick of one grind and three burns (cone 15 to cone 19)	Modulus of rupture	389	655	701
	Specific gravity	2.340	2.343	2.343
	Residual permanent expansion	.00	1.20	1.20
	Per cent porosity	26.70	27.94	25.53

TABLE VIII—EFFECT OF BURN UPON CHARACTERISTICS OF BRICK OF SERIES II

	Average value for all grinds at each cone			
Temperature of burn in cones	Specific gravity	Residual permanent expansion	Modulus of rupture	Per cent porosity
14–15	2.38	2.0%	533	26.38
17	2.33	.8%	590	26.49
19	2.32	.6%	622	27.30

second lot of samples confirmed those already reported, although the effect of grinding 6 minutes should be discussed more in detail.

The results of all the tests were plotted so as to study the influence of the time of grinding upon the strengths of the brick. It developed that there was a slight increase in strength (14 per cent) when the first mix was ground 20 minutes instead of 10. It also developed that there was a marked increase in strength (68 per cent) when the grind of the second lot was increased from 6 to 13 minutes. No important increase (7 per cent) was noted when the grind was extended from 13 to 20 minutes. It might be stated,

however, that the 10, 13, 15, and 20 minute grinds for this material are within the limits of commercial work which the 6 minute grind is not.

An attempt was then made to determine to what degree the mud should be ground in order to produce a strong brick. The mixes studied were properly ground after 10 and 13 minutes but were not sufficiently ground after 6 minutes. Other raw materials, however, grind with more or less difficulty. The terms fine, coarse, and medium are not exact. When the screen analyses were studied it was found that the 10 and 13 minute grinds gave muds with remarkably similar analyses. These analyses follow:

TABLE IX

Time of grind in minutes	10	13
Per cent on 10 mesh	17.8	19.5
Per cent on 20 mesh	6.0	4.0
Per cent on 40 mesh	10.8	7.3
Per cent on 60 mesh	17.2	19.8
Per cent on 80 mesh	12.0	14.4
Per cent on 100 mesh	5.0	5.6
Per cent on 120 mesh	3.8	4.0
Per cent on 140 mesh	.5	.3
Through 140 mesh	27.0	25.1

While this remarkable similarity may be simply a coincidence it is known that when silica mud has an analysis similar to these little additional strength can be gained by longer grinding. When the mud is coarser (as shown by the analysis of the 6 minute grind) the bricks may be weak because of insufficient grinding.

From the practical standpoint it might be stated that changes in commercial grinds as now made, do not seriously change the strength of silica bricks. The porosity of silica bricks is not seriously affected by the grind. The strength and amount of residual expansion of silica bricks is controlled almost entirely by the burning temperature.

MELLON INSTITUTE OF INDUSTRIAL RESEARCH
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RESISTANCE TESTS ON FIRE BRICKS UNDER LOADS AT HIGH TEMPERATURES[1]

By E. Sieurin and Fredr. Carlsson[2]
Experiments carried out by B. Kjellgren

ABSTRACT

Method.—Mixtures of fine ground china clay and ball clay with grog (called by the author "chamotte") of the same materials were made into 3 cm. cubes and subjected to a pressure of 2 kg. per sq. cm. at temperatures which sufficed to bring about a linear contraction of 0.3 per cent in 2 hours. Definite quantities of silica, alumina, ferric oxide, lime and magnesia were added and both the deformation and the usual softening points determined.

Results.—Even very small amounts of the oxides of iron, calcium and magnesium brought about a considerable reduction in the resistance to pressure. A minimum in the resistance was observed with silica contents between 60–70 per cent, which does not correspond to the minimum softening point or melting point of clay-silica mixtures. Additions of alumina increased the temperature required to deform the specimens but with high alumina content mechanical failure due to lack of bonding material occurred. For many purposes clay fire brick will have to be replaced by more resistant materials, such as brick made from silica, aluminous mixtures and silicon carbide.

Formerly, when judging the properties of fire bricks, great importance was attached to the melting point (shown by Seger cones) and to the chemical composition, as regards ordinary fire bricks to the alumina contents particularly. Experience, however, has shown that such determinations do not fully indicate the properties of these refractory products. It has become more and more evident that the importance of determining the melting points by Seger cones has been over-estimated. This is especially the case with fire clay material owing to the fact that this material shows a considerable softening interval between 300° and 400°C.

Investigators, therefore, soon endeavored to find other methods which would better illustrate the real properties of the materials

[1] Received December 31, 1921.

[2] Communicated by the Laboratory of the Höganäs Works at Höganäs, Sweden.

and they discovered a particularly good method for this purpose in the determination of the resistance under load at high temperatures.[1]

In carrying out such investigations it will frequently be noticed that even slight variations in the chemical composition cause important changes in the resistance under load at high temperatures. It may therefore be of interest to examine the influence of variations in the chemical composition. The following investigations have been carried out with this object.

As is known a fire brick is made of a mixture of raw clay and grog. Obviously when investigating the influence of a substance upon the properties of a material, this substance must be extremely intimately mixed with the binding clay as well as with the grog. These investigations were therefore carried out in such a manner that a normal clay of known composition was minutely wet-ground during 12 hours in a ball mill along with the substance being examined. By means of screening, it was found that no residue was left after passing through a 10,000 meshes per square centimeter.

One part of this very finely ground mixture was burnt to chamotte at cone 14 (1410°C), then crushed and screened partly to grains between screens No. 4 and No. 20 (*i. e.*, 4 and 20 meshes per lineal inch, respectively), partly to a product finer than No. 7 (*i. e.*, 7 meshes per lineal inch). The different kinds of chamotte were then mixed with raw clay in the proportions of one part chamotte to one part raw clay and cubes a little more than 30 mm. square were formed with this mixture. Cubes were made of each mixture partly with chamotte screened through 7 meshes and partly with chamotte in grains between 4 and 20 meshes, *i. e.*, with the fine powder sieved away. These cubes were then burnt at cone 14 and afterwards cut as exactly as possible to 30 mm. square.

Certain quantities of SiO_2, Al_2O_3, Fe_2O_3, CaO and MgO were added to the raw mixture. With each mixture the fusion point was determined in the usual manner by cone as was also the softening temperature. The latter is defined as "the temperature at which the test cube exposed during two hours to a load of 2 kilos

[1] Cf. K. Endell, "Über das Verhalten feuerfester Steine unter Belastung bei hohen Temperaturen," *Stahl u. Eisen*, **1921** H. 1.

per square cm. experiences a lineal contraction of 0.3 per cent of the original length."

The heat took place in an electric resistance furnace, the resistor consisting of granular (14–29 mesh) retort carbon contained between two vertical coaxial tubes of carborundum.

A carborundum rod with its upper surface at the center of the furnace served as the support for the test tube and the Seger cones. Pressure was applied to the test piece by means of a loaded rod of carborundum.

Investigations proceeded simultaneously in 4 furnaces, connected as shown in Fig. 1, so that an exact regulation of the electric current could be arranged by means of a liquid resistance. The main current from the transformer was regulated by means of a water-cooled iron wire resistance. The furnaces were coupled on a transformer with a secondary tension of 110 volts; consequently each furnace received about 55 volts. The load for each furnace was about 35 kw. at 1500°C and about 20 kw. at 1350°C.

Coupling scheme.

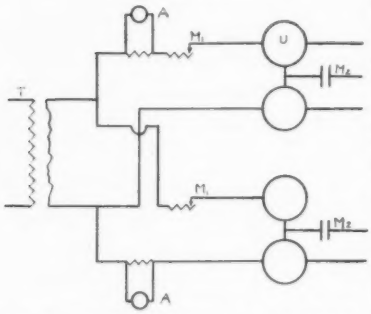

FIG. 1.—T, Transformer; A, Ampèremeter; M_1, Iron wire resistance; M_2, Liquid resistance; U, Furnace.

The tests were carried out in these comparatively large furnaces in order to enable the temperature to be kept as steady as possible. The temperature was determined by means of Seger cones which were placed in the furnaces at certain intervals.

The tubes, as well as the pressing rod of silicon carbide proved to be extremely suitable for the purpose. The tubes were used during months of testing and they were often suddenly cooled without cracking. When the cubes were changed, the pressing rods were frequently taken out while white hot, but in spite of this they did not crack.

The temperature was regulated in the following manner: For the determination of the desired temperature, for instance that of cone 10, the cones numbers 9, 10 and 11 were set down in

the furnace whereupon cone 9 bent down suddenly, cone 10 bent little by little until the point touched the bed, while cone 11 did not bend. The furnace being so exactly regulated that cone 11 remained unbent, the temperature was considered as having been reached. During the carrying out of the experiments, new cones numbers 9 and 10 were set down every hour, and in this manner the temperature could easily be kept practically constant during each testing period. The furnaces were often running day and night in order to avoid the heating periods. As showing the exactness of the regulation of the temperature it may be stated that during a period of 6 to 8 hours the point of each new cone 10 touched the bed after one hour exactly.

In order to determine the softening temperature for a test mixture, a series of pressure tests was carried out, first at high temperature and then at temperatures lower and lower, until, finally, the test cube was no longer compressed. The softening temperature was considered to have been reached at a contraction of 0.3 per cent. For instance, on pressing the original material, the following results were obtained:

Cone	Per cent contraction at the end of 2 hours
11	2.9
11	3.2
10	0.9
10	1.2
9	0.3
9	0.2
8	0.0
8	0.0

The softening temperature is consequently to be found between cone 9 and cone 10, but nearer cone 9.

The primary mass consisting of 1 part blue clay and 1 part washed china clay, gave the following analysis (after calcination).

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	Total
54.52	43.04	0.89	0.68	traces	0.78	0.0	99.91

Fusion point given as cone 34 (1750°C).

To this mixture certain quantities of SiO_2, Al_2O_3, Fe_2O_3, CaO, and MgO were added in the purest possible form. The silicious material was added in the form of the purest quartz, the alumina,

oxide of iron and magnesia in chemically pure form, and the lime as chemically pure precipitated chalk. The Seger formula was calculated from the original analysis and on the basis of this a certain number of moles of the different oxides were added (see the various tables). The percentages were all *calculated*.

Increase of the Percentage of Silica

The silica was added in the form of quartz with SiO_2 content about 99 per cent.

The different mixtures and the results of the investigation are shown in Table I and Fig. 2. The underlined figures indicate the cones most nearly corresponding to the temperature in question.

TABLE I

Number of SiO_2 moles to the mixture	Percentage of SiO_2 in the raw clay	Percentage of SiO_2 in the mixture	Melting point given as cone	Softening temp. chamotte 4–20 mesh	Softening temp. chamotte 7 mesh	Number of pressure tests
0	54.52	54.52	*34*–35	*8*–9	9	20
5	54.52	57.2	33–*34*	7–*8*	8–*9*	24
15	54.52	61.6	32–*33*	*7*–8	*8*–9	18
30	54.52	66.7	31–*32*	*6a*–7	*7*–8	18
60	54.52	73.8	29–*30*	*8*–9	*9*–10	22
100	54.52	79.6	28–*29*	*10*–11	10–*11*	24
...	...	86.8	27–28	...	...	..
...	...	90.3	26–*27*	...	...	..
...	...	93.9	29–30	...	...	..
...	...	96.4	30	...	...	..

The results of the experiments are graphically shown in Fig. 2.

From this sketch it will be seen that a definite minimum for the softening temperature exists between 60 and 70% silica content. At 60 and 70% silica content the softening temperature is almost the same and, in both cases, exceeds the temperature for about 67% silica content by about 25°C. The minimum for the softening temperature sets in consequently at a considerably lower percentage of silica (between 60 and 70 per cent) than for the cone melting point, for which the minimum lies at about 90 per cent of silica.

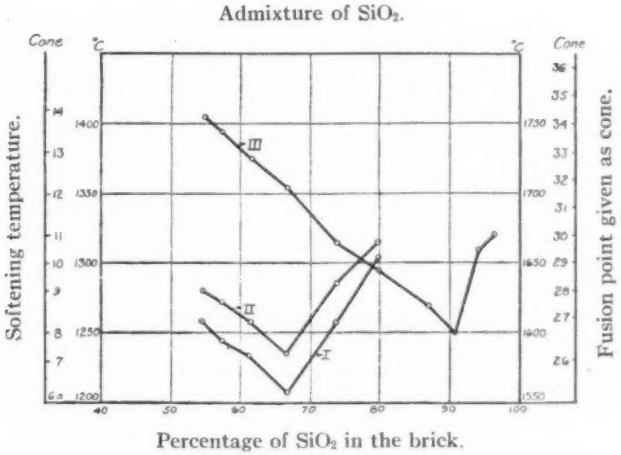

FIG. 2.—Curve I, Softening temperature chamotte 4–20 m.
Curve II, Softening temperature chamotte 7 m.
Curve III, Fusion point given as cone.

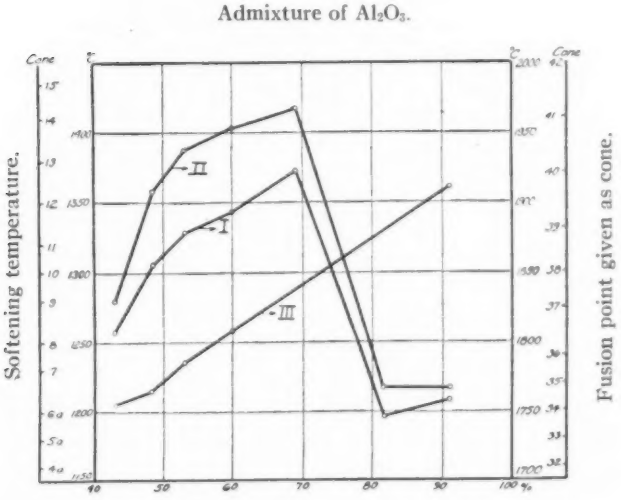

FIG. 3.—Curve I, Softening temperature chamotte 4–20 m.
Curve II, Softening temperature chamotte 7 m.
Curve III, Fusion point given as cone.

With a higher percentage of silica, the softening temperature rises rapidly, attaining about 1650°C when the percentage of SiO_2 reaches about 95 (*i. e.*, the usual average for silica bricks).

From the curves it will be seen that in all cases the coarse-grained mass gives a considerably lower softening temperature than the fine-grained mass, which is certainly due to the presence of certain hollows which cause a more rapid contraction. The fact that the coarse-grained mass shows a lower softening temperature was observed in most of the tests.

Increase of the Percentage of Alumina

Alumina was added in the form of calcined chemically pure alumina and the results obtained are shown in Table II and Fig. 4.

TABLE II

Number of Al_2O_3 moles added to mixture	Percentage of Al_2O_3 in the raw clay	Percentage of Al_2O_3 in the mixture	Melting point given as cone	Softening temp. chamotte 4–20 mesh	Softening temp. chamotte 7 mesh	Number of pressure tests
0	43.04	43.0	*34*–35	8–9	9	20
5	43.04	48.4	34–*35*	*10*–11	*12*–13	20
10	43.04	52.9	35–*36*	*11*–12	*13*–14	24
20	43.04	59.8	36	11–*12*	13–*14*	22
40	43.04	68.9	36	12–*13*	*14*–15	22
100	43.04	81.5	36	5a–*6a*	*6a*–7	28
250	43.04	90.8	39–*40*	*6a*–7	6a–7	28

With an increased percentage of alumina, the softening temperature rises continuously. The sudden fall noticed with a very high percentage of alumina (about 80 per cent Al_2O_3) is probably due to the fact that the small quantity of binding clay is not sufficient to keep the alumina grains together. It is not a real softening temperature which is observed here but a sudden collapse owing to the lack of binding material. As in Table I, the fine-grained mixture shows a considerably higher softening temperature than the coarse-grained.

Increase of the Percentage of Oxide of Iron

Chemically pure oxide was added. The result of the investigations are shown in Table III and Fig. 5.

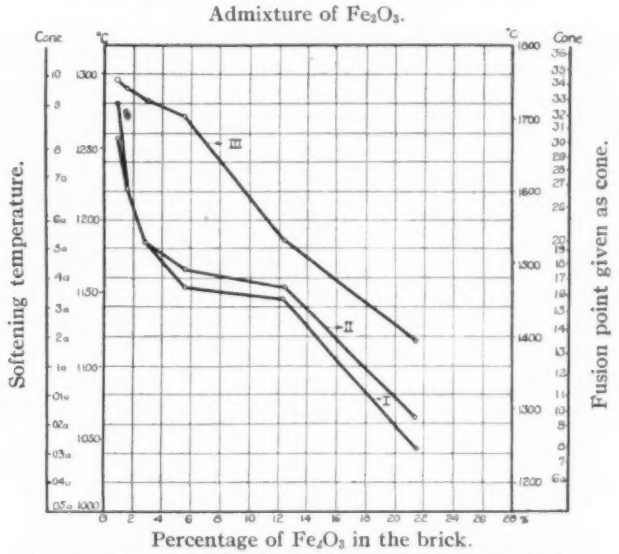

FIG. 4.—Curve I, Softening temperature chamotte 4–20 m.
Curve II, Softening temperature chamotte 7 m.
Curve III, Fusion point given as cone.

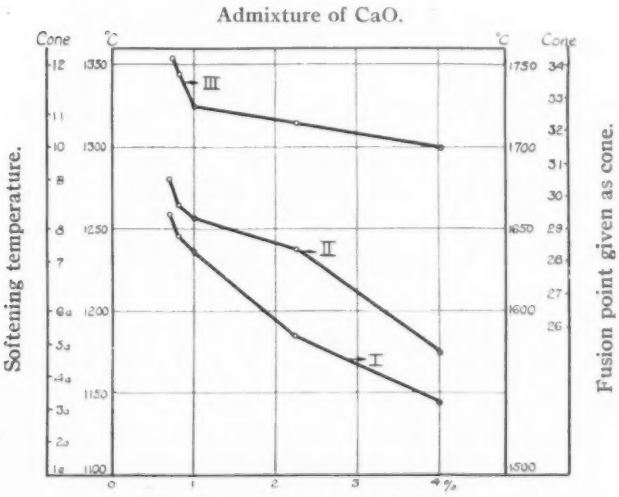

FIG. 5.—Curve I, Softening temperature chamotte 4–20 m.
Curve II, Softening temperature chamotte 7 m.
Curve III, Fusion point given as cone.

TABLE III

Number of Fe_2O_3 moles added to the mixture	Percentage of Fe_2O_3 in the raw clay	Percentage of Fe_2O_3 in the mixture	Melting point given as cone	Softening temp. chamotte 4–20 mesh	Softening temp. chamotte 7 mesh	Number of pressure tests
0	0.89	0.89	*34*–35	*8*–9	9	20
0.2	0.89	1.53	33–*34*	6a–*7*	6a–*7*	22
0.6	0.89	2.79	32–*33*	*5a*–6a	*5a*–6a	22
1.5	0.89	5.51	31–*32*	3a–*4a*	*4a*–5a	24
4.0	0.89	12.32	20 near	*3a*–4a	3a–*4a*	22
8.0	0.89	21.40	13–14	*03a*–02a	*02a*–01a	22

An increase of the percentage of iron oxide by 0.64 caused a lowering of the softening temperature of 50°C. After this point the softening temperature declines more slowly so that it is nearly constant between 6 and 12 per cent Fe_2O_3, falling more rapidly if the percentage of iron oxide is further increased.

Curiously enough, this curve does not show the same difference between coarse and fine grains as do all the other mixtures.

Increase of the Percentage of Lime

The lime was added as chemically pure precipitated chalk. The results are given in Table IV and Fig. 6.

TABLE IV

Number of CaO moles added to the mixture	Percentage of CaO in the raw clay	Percentage of CaO in the mixture	Melting point given as cone	Softening temp. chamotte 4–20 mesh	Softening temp. chamotte 7 mesh	Number of pressure tests
0	0.68	0.68	*34*–35	*8*–9	0	20
0.1	0.68	0.79	33–*34*	7–*8*	8–9	22
0.3	0.68	1.02	32–*33*	7–8	*8*–9	22
1.4	0.68	2.25	*32*–33	*5a*–6a	7–8	20
3.0	0.68	3.98	31–32	*3a*–4a	4a–*5a*	22

The softening temperature is considerably reduced by a slight increase of the lime content. For instance an increase of 0.11 per cent CaO causes the softening temperature to fall about 25°C. With a further increase, the softening temperature falls less rapidly, although, of course, the extremely bad influence of this impurity is easily seen from the diagram.

As the strong influence of so small an increase of lime from 0.68 to 0.79 per cent is distinctly apparent, a material with a still smaller percentage of lime than the raw mixture will certainly show a much higher softening temperature. Investigations are now being made to ascertain the softening temperature with a lime content even lower than 0.68 per cent.

In this case also, the influence of the fineness of the grog may be distinctly observed.

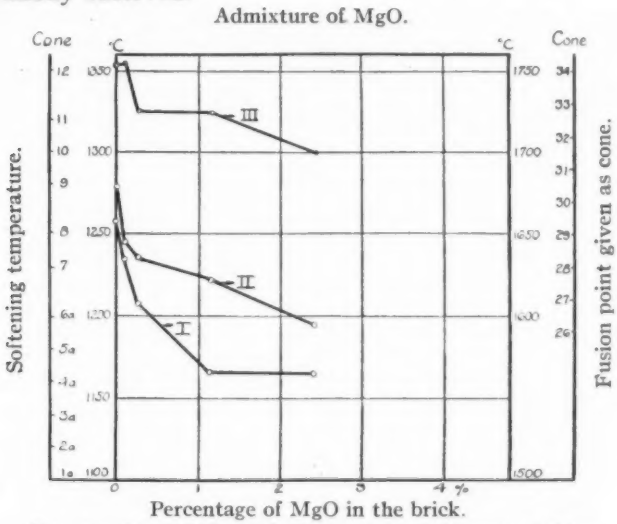

FIG. 6.—Curve I, Softening temperature chamotte 4–20 m.
Curve II, Softening temperature chamotte 7 m.
Curve III, Fusion point given as cone.

Increase of the Percentage of Magnesia

The results of the investigation are given in Table V and Fig. 7.

TABLE V

Number of MgO moles added to the mixture	Percentage of MgO in the raw clay	Percentage of MgO in the mixture	Melting point given as cone	Softening temp. chamotte 4–20 mesh	Softening temp. chamotte 7 mesh	Number of pressure tests
0	0.00	0.00	*34*–35	*8*–9	9	20
0.1	0.00	0.08	*34*–35	*7*–8	7–*8*	20
0.3	0.00	0.25	32–*33*	*6a*–7	*7*–8	18
1.4	0.00	1.14	32–*33*	*4a*–5a	6a–*7*	20
3.0	0.00	2.41	31–32	*4a*–5a	5a–*6a*	20

As in the case of lime, a slight increase in the percentage of magnesia has a strong influence in lowering the softening temperature, but to an even greater extent than with lime. Thus an increase of the percentage of MgO from 0 to 0.08% causes the softening temperature to fall from 1280° to 1240°C.

With 1 per cent of magnesia, the softening temperature is 1220°C for the fine-grained mixture, while 1 per cent of CaO reduces the softening temperature only to 1260°C.

In this instance also a great difference can be observed between coarse- and fine-grained masses.

CARBORUNDUM BRICK[1]

By M. F. Peters[2]

ABSTRACT

A study of carborundum-clay mixtures with reference to the relation between the proportioning and sizing of the constituents and the properties of the refractory as expressed by the tensile strength, the load test, the slagging and the spalling tests. For good working conditions the amount of clay must suffice to cover the grains of SiC. When subjected to crushing the linear compression varies as the second power of the percentage of carborundum. Oxidizing furnace conditions and the presence of iron oxide, lead oxide and lime reduce the resistance to slag action. The resistance to spalling depends upon the content of SiC, the tensile strength, the coefficient of expansion and the thermal conductivity of the clay. A formula is proposed for the estimation of the life of the carborundum refractories, and a theoretical explanation of their physical properties is offered.

I. Introduction

1. Outline of Discussion.—That carborundum can replace saggers, flint, dobies, and other grog materials in fire brick is still an open question, yet one, which seems to warrant considerable attention. While some work has been done along this line, very little has been published which covers the subject as thoroughly as desirable. In this paper an attempt has been made to present the general idea underlying the use and advantages of carborundum brick, thus making it possible to decide in advance the advisability of using this material under any given set of conditions. Below is given the outline which will be followed throughout this discussion.

II. Mixtures.

III. Methods adopted for testing carborundum bricks.

IV. Development of a formula by which we may compare carborundum bricks with clay bricks.

V. Fabrication of carborundum bricks.

[1] Received November 10, 1921.

[2] Published by permission of the Chief of Research, New Jersey Zinc Company.

VI. Results obtained from test bricks.
VII. Theoretical explanation for the physical properties of carborundum bricks.
VIII. General conclusions.

II. Mixtures

2. Proper Sizing of Carborundum.—As data is obtained on refractories it is being realized that the inert material plays a very important rôle. Not only must care be exercised in selecting a substance which has the proper chemical composition, but judgment must be used in sizing. From tests conducted by Fulton and Montgomery[1] using bodies which contained 50% St. Louis Fire Clay and 50% grog by weight, it was found that the modulus of rupture in the raw state increased from 6 to 100 mesh grog, and then decreased with the 200 mesh. In the burned state up to cone 15 the strength increased with decrease of grog size. The porosities at cone 15 were 10–13% for 6–14–35 mesh bodies, and 5–6% for 100–200 mesh bodies.

While strength is very desirable it must not be forgotten that certain refractories require a dense material capable of withstanding rapid changes in temperature. The first is obtained by the use of fine grog, which however, destroys the second. It has been found that refractories containing proper proportions of 8 to 40 mesh grog withstood the quenching test better than those with the finer sizes. Another bad feature in using fine grog is that the fusion point is lowered, and unless care is used in selecting materials the refractories may fail.

In dealing with carborundum, however, we have an entirely different material. In the first place, the temperature of decomposition is far above any temperature reached in the furnace, so that the fusion point of the brick will not be lowered by using the finer sizes. Again, the rate of spalling of carborundum brick is small, so that we should not expect much trouble from rapid changes in temperature. From the above it seems that by using carborundum we can obtain a very dense mass without the disadvantages which usually accompany other grogs.

Upon a second consideration, however, it may not be advanta-

[1] "The Effect of Grog in Fire Clay Bodies," *Trans. Amer. Cer. Soc.*, **17**, 409.

geous to use the finer sizes. Since one of the big arguments in favor of carborundum is its higher thermal conductivity it can be seen that the more carborundum and the less clay used the nearer will this condition be realized. Heat in passing through the brick must pass through both the clay and carborundum. Each particle of carborundum must be surrounded by clay, so that the heat will pass through what might be considered several layers of clay and carborundum. In case the carborundum is fine, the number of layers of clay will be great, the heat conductivity being thus impaired. On the other hand, if the material is coarse, the number of layers of clay will be small, and the conductivity great. Of course, if only one size of coarse material is used we will need considerable clay to fill the voids, but this can be remedied by adding sufficient fine carborundum. Our problem then is to so proportion the sizes of carborundum particles that we will obtain a mixture of maximum density, as it is very essential that the thermal conductivity of these brick be high. A few experiments will bring this out more clearly and show us what sizes should be mixed together.

If 100 grams of carborundum which has passed through 200 mesh is put into a graduated tube so that its volume may be accurately measured we find that it occupies 65 cc. As we continue to measure the volume of these mixes we find that as the size increases the volume decreases, and for 35 mesh the volume is 58 cc. per 100 grams. If now 30 grams of 28 mesh carborundum are mixed with 10 grams of each of the following, 35, 48, 65, 100, 150, 200, +200 mesh we find that its volume has been reduced to 48 cc., in other words, for a brick composed entirely of carborundum we can increase its weight $\frac{(65-48)}{48} = 35.4\%$. Since clay must be added as a bond these figures will change, the change tending to make this ratio greater. In the case of fine material 40% clay must be added while in the latter only 25% should be used. This percentage of clay will be discussed in the following section.

From the above it is quite evident that to increase the thermal conductivity the sizes should be so proportioned that we have a maximum amount of coarse, but sufficient fines must be added

to fill the voids. It will be shown later that this mixture stood up the most satisfactorily during the test, and that this is the proper mixture from a theoretical standpoint.

3. Percentage of Clay to Add to Carborundum.—Whenever two substances are mixed in which one is the inert material and the other is the bond, it is necessary and sufficient to fulfill these two requirements: (1) cover each particle of inert material with bond, (2) fill the voids between these particles.

To accomplish the first and use a minimum amount of bond it is necessary to use a very coarse material, as the ratio of surface to volume is small. With a decrease in size, however, this increases very rapidly. To use a minimum amount of bond in the second case it requires a very fine material, for here the voids[1] are small. Since the quantity of bonding material is the sum of these two factors, and when the first case requires a minimum the second requires a maximum, or, vice versa, we know that there is some size where the sum of the two is a minimum. What seems to be a more reasonable solution than this is one in which we have a mixture of several sizes. In this case we have the coarse material requiring very little bond to cover its surface, while the smaller sizes fill up the voids. Perhaps the best method of answering this question is to follow out a few cases of proportioning sizes, together with the method adopted for calculating the quantity of clay required.

Method: When sufficient water is added to carborundum it wets the surface of each particle and fills the voids, the quantity of water varying with these two factors. The quantity of water is then a measure of the required volume of clay, for it distributes itself throughout the mix in the same manner as the bond. Knowing the specific gravity of clay (2.55) and the volume required, the product of these two factors will give the weight. Four problems will bring this out more fully.

(1)—It requires 27 cc. of water to cover 100 grams of carbo-

[1] If we have spherical particles of diameter A the ratio of volume to voids is a constant regardless of the values given to A. With carborundum the ratio of volume to voids is not a constant but increases with an increase in size. This is probably due to the irregular shape of the carborundum particles.

rundum which has passed through a 200 mesh screen. What weight of clay is required? What is the percentage of clay in the mixture?

$27 \times 2.55 = 68.8$ grams of clay per 100 grams of carborundum or, 688 pounds of clay per 1000 pounds carborundum.

$$\frac{688}{1688} = 40.7\% \text{ clay in mix.}$$

(2)—Some coarse material required 32 cc. of water per 100 grams of carborundum. What weight of clay is required and what is the percentage of clay in the mixture?

$10 \times 32 \times 2.55 = 816$ pounds of clay per 1000 pounds of carborundum.

$$\frac{816}{1816} = 44.9\% \text{ clay in mix.}$$

(3)—The carborundum used in problem (2) was ground and made into bricks. It was found to require 17 cc. of water to cover 100 grams of the material. What weight of clay should be used per 1000 pounds of carborundum? What was the percentage of clay in the mixture?

$10 \times 17 \times 2.55 = 434$ pounds.

$$\frac{434}{1433} = 30.2\% \text{ clay in mix.}$$

(4)—When 30 grams of 28 mesh and 10 grams each of 35, 48, 65, 100, 150, 200, +200 mesh were mixed it was found to require 13 cc. of water. What weight of clay is required per 1000 pounds of carborundum? What per cent of the mix is clay?

$10 \times 2.55 \times 13 = 332$ pounds.

$$\frac{332}{1332} = 24.9\% \text{ clay.}$$

In using this method to determine what percentage of clay is required the following procedure is recommended: (*a*) Weigh up a definite weight of carborundum, say 100 grams. (*b*) Add 100 cc. of water. (*c*) Remove all entrapped air. (*d*) Allow to stand until settled. (*e*) Subtract water above carborundum from 100. (*f*) Multiply (100—water above carborundum) by 25.5 which gives number of pounds of clay to add to 1000 pounds of carborundum.

4. Tensile Strength of Various Mixtures of Carborundum and Clay.—In Fig. 1 we have a curve showing the relation between the tensile strength of various percentages of carborundum and Grand View Fire Clay. These briquettes were all mixed from the raw materials, rotted, moulded, dried and burned together at 1000°C. These tests show that as the percentage of carborundum is increased the tensile strength increases very rapidly at first, then remains practically constant and finally falls off very rapidly. In this particular case the maximum strength is obtained with approximately 45% carborundum. In mixtures of carborundum and certain ball clays the maximum tensile strength was obtained with 70% carborundum, so that it is impossible to say what proportions of carborundum should be used with any clay to obtain the maximum tensile strength, unless briquettes have actually been made and broken.

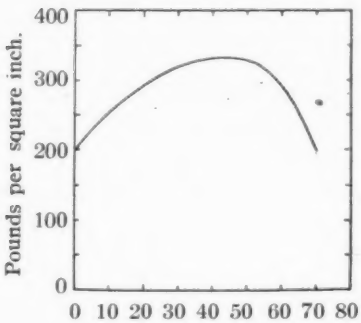

FIG. 1.

Tensile strength of Grand View fire clay.

III. Methods Adopted for Testing Carborundum Bricks

While there are a great many reasons for fire bricks failing it was thought that in this particular furnace where these bricks were used failure would be due to a combination of the decrease in resistance to deformation at high temperatures, slagging, and spalling.

It was found after the work had been completed that the abrasive action while small should have been considered. This will be discussed later.

5. Decrease in Resistance to Deformation at High Temperatures.—A measurement of the resistance to deformation at high temperatures of a refractory material is really a measure of the

decrease in its viscosity.[1] These measurements were made using the furnace shown in Fig. 2 which is the improved Case Melting Furnace No. 24 of the Denver Fire Clay Company. It is heated by 2 low pressure burners using fuel oil. The burner is supplied by the same company. The brick to be tested is dried at 110°C for 5 hours, measured, and then placed upon a heavy carborundum brick held in place by carborundum cement. A half carborundum brick is placed upon the test brick and then high grade fire brick built up which extends through a hole in the cover.

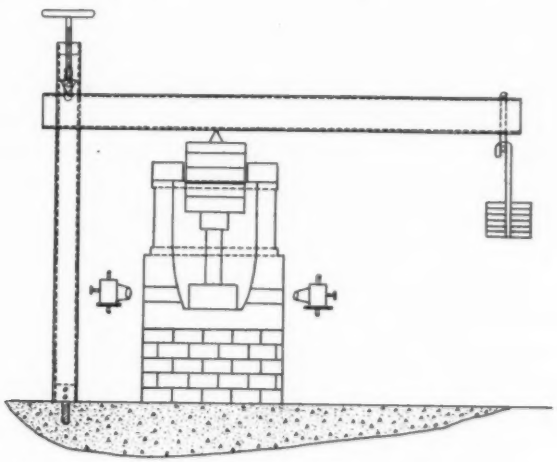

FIG. 2.

Upon the upper brick is placed a cast iron knife edge through which the load is applied by means of an I beam 6 feet long. The distance between the knife edge taking the upthrust and the fulcrum is 2 feet, and the distance between the fulcrum and the point of application of the load is 4 feet. The downward thrust at the fulcrum due to the weight of the beam was determined by means of a platform scale placed in the same position as the brick. The applied load consisted of circular iron plates and was also calibrated within the limits of the scales. The knife edge taking

[1] *Bur. Standards, Tech. Paper*, No. **7.** "The Testing of Clay Refractories with Special Reference to Their Load Carrying Capacity at Furnace Temperatures."

the upthrust acted against a screw so that the beam could be kept level throughout the test. The load upon the test brick was 50 pounds per square inch.

With the test brick in place, the temperature was raised to 1350°C at the rate of 6.50°C per minute. This temperature was maintained for 2 hours, after which the supply of heat was shut off. The load was not removed from the brick until the furnace had cooled down.

6. Slagging Test.[1]—Upon the smooth side of the bricks selected for the test 2 rings were placed so that their centers did not approach closer than 2 inches from the sides of the brick, or their centers lie closer than $4^1/_2$ inches apart.

The rings were $2^1/_2$ inches, inside diameter, $^1/_2$ inch deep, and had walls $^1/_2$ inch thick. They were made from the same material as the brick under test and were cemented on with carborundum cement.

The slag[2] used was mixed from chemically pure materials, melted in a plumbago crucible, and crushed to pass a 48 mesh screen. The analysis of the slag showed it to have the following composition:

SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	MnO	Na_2O	Total
23.26	16.27	17.35	25.00	8.54	3.90	6.20	100.52

This conforms closely to slags encountered in metallurgical work.[3] Thirty-five grams of the powdered slag were put in the ring and equally distributed. The brick was then placed upon a level hearth, cold, and the temperature gradually raised to 1350°C, 5 hours being allowed to bring the brick to the above temperature. This temperature was maintained for 2 hours.

When cold the bricks were broken so that one of the broken surfaces bisected the center of the rings. The distance which the slag had penetrated or discolored the bricks was measured and the area calculated by Simpson's,[4] or the trapezoidal rule.

[1] Taken from the *American Society for Testing Materials*, **19**, 586.

[2] This is approximately the slag recommended by the A.S.T.M.

[3] According to A.S.T.M. the brick should be placed on the cold level hearth of a furnace and allowed not less than 5 hours to attain 1350°C. The thirty-five grams of slag are then introduced. Due to the construction of our furnace it would be very difficult to introduce the slag at 1350°C.

[4] Planimeter recommended.

7. Spalling Test.—The spalling tests were made as follows: A brick free from cracks was dried for at least 5 hours at 110°C. This brick was placed in the furnace which was heated to 1350°C so that one-half of it was exposed to the flame, one-fourth imbedded in the cover of the furnace, and one-fourth projected clear through. The brick was heated for 30 minutes, removed and the half-heated portion was plunged into 6 kg. of water whose initial temperature was 20°C and allowed to remain 3 minutes. The brick was then removed from the water and all loose pieces were broken off. After cooling in the air for three minutes the brick was replaced in the furnace. The pieces broken off after each cooling were weighed. This heating and cooling of the brick was repeated 10 times unless the brick failed before.

The furnace used in this test was the one with the beam removed described above. Brick work was built up to within one-half brick length of the top of the furnace. Two bricks were tested at a time by placing them on top of this column of brick, the free ends passing through the cover. Gases were prevented from rising between the bricks and the cover by means of small briquettes set in to fill the cracks.

IV. Development of a Formula by Which We May Compare Carborundum Bricks with Clay Bricks

Before subjecting any bricks to these tests it was thought advisable to see if a relation could not be found between the results obtained from the test bricks and the length of time similar bricks would last in the furnace. This relation should be expressed by some numerical value and could then easily be compared with other brick whose numerical value had been determined. This numerical value should be based upon results obtained from standard tests, thus making it possible to calculate the value from previous work. It should take into consideration the various agents of destruction which the brick must be called upon to resist, and should be applicable to any brick for any work.

In consideration of this problem it is natural to look upon the life of a brick as a function of the various destructive agents. If we accept this analogy as holding true, at least formally so, then

the life of a brick is proportional to the sum of all the destructive forces and our first step will be to define some of the terms which will be used throughout this discussion.

The predicted life of a brick may be defined as that number which represents the total number of days the brick may be expected to give useful service.

The destructive action may be defined as the sums of all the destructive forces when each force is weighted according to the results of the test.

$$\text{The rate of destruction} = \frac{\text{destructive action}}{\Delta T} = \frac{\Delta S}{\Delta T}$$

The relation between the predicted life of a brick and the destructive action may best be shown by the expressions:

$$\text{destructive action} = \frac{K}{\text{predicted life of a brick}},$$

$$\text{or, predicted life of a brick} = \frac{K}{\text{destructive action}}.$$

This expression states that the life of a brick is inversely proportional to the destructive action, and that when the destructive action is small the life of a brick becomes great, and vice versa.

Let us consider a brick which has been subjected to some one destructive agent, say slagging, and the length of time it has resisted this action before failing be known. Let us represent the result from the slagging test on this brick by Δp. Then Δp is a measure of its resistance to destruction by slagging, and its rate of destruction over the test period may be expressed by the secant $\Delta p/\Delta t$, where the curve $t=f(p)$ represents the relation between slag penetration and time. The actual shape of this curve is not known or required, because we are only interested in the secant $\Delta p/\Delta t$ which is obtained from the test brick.

If now the secant $\Delta p'/\Delta t$ for some unknown brick is obtained we have, since destructive action $= \Delta p$, the life L'_p of the unknown equal to $\frac{K}{x(\Delta p')}$.

By a similar process of reasoning we may obtain similar expressions for L_c and L_s where

$$L_c = K_2/x_2(\Delta c) \text{ and } L_s = K_3/x_3(\Delta s)$$

if L_c = the predicted life when the brick is subjected to pressure alone, and L_s = the predicted life when the brick is subjected to changes in temperature alone.

If now we have two destructive forces acting, say slagging and compression, the total destructive action may be given approximately by the expression $y_1(\Delta s)+y_2(\Delta c)$ and for any number of such agents we have approximately $z_1(\Delta s)+z_2(\Delta c)+z_3(\Delta p)\ldots\ldots$

By definition the life becomes:

$$L = \frac{Kn}{z_1(\Delta s) + z_2(\Delta c) + z_3(\Delta p)\ldots\ldots}$$

where z_1, z_2, z_3, represents the relative importance of the destructive action for any particular use to which the bricks are to be put, and will be referred to as the weight assigned to these destructive forces.

Let the quantity Δc represent the results from the load test, Δp the results from the slagging test, and Δs the results from the spalling test. It is perfectly obvious that if a given brick were subjected to the above 3 destructive agents it would outlast a similar brick subjected to a fourth destructive agent such as abrasion. Again, if this same brick were subjected to one of the above destructive agents it would last longer than when all 3 were acting. In this way it can be easily seen that the greater the number of destructive agents the shorter will be the life of the brick. Hence, in selecting a brick for any one job we must consider the destructive agents which are called into play. As an example, bricks which are used for lining flues, have a temperature which is fairly constant and the spalling action may be neglected. The load upon the brick is small but the slagging and abrasive action is appreciable. In this case the predicted life of a brick is equal to $k/(z_1(\Delta p)+z_2(\Delta a))$ where Δa represents the results from the abrasion test.

In the case of a blast furnace where we have a load acting, fluctuations in temperature, slagging, and abrasion, the average predicted life of the brick is equal to

$$\frac{Km}{z_1(\Delta c) + z_2(\Delta s) + z_3(\Delta p) + z_1(\Delta a)}.$$

Having obtained Δc, Δs, and Δp, from the test, it is necessary to put these values into a suitable form to substitute in the equation. We shall follow 2 rules in this calculation, first, that a brick which fails completely is 100% imperfect and one which stands up absolutely is 0% imperfect; second, a brick which fails partly during any period of a test is better than one which fails completely.

8. Calculations of Δ_c, Δ_p and Δ_s.—If a brick were completely crushed or failed during the load test we would record it as a 100% imperfect brick. If out of 3 bricks tested 3 should fail then this would be recorded as a grade of brick 100% imperfect as far as the load test was concerned. If two should fail we would multiply the per cent linear compressions of the brick which did not fail by $\frac{3}{3-2} = 3$ so that Δc becomes $\frac{L \times T}{T - F}$. L = average per cent linear compression of the brick which did not fail, T = number of bricks tested, and F = number of bricks which failed.

To calculate Δp we shall assume that when the slag has penetrated the depth of the brick straight down from the inner sides of the ring the brick has completely failed. If on the other hand no penetration has taken place the brick has failed 0 per cent. Hence to calculate the above quantity we need only find the percentage of area destroyed. The expression for this is $p = \Delta A / A \times 100$. Where A = depth of brick $\times$ diameter of ring = 36 sq. cm. in these test brick, A = area destroyed by slag.

To calculate Δs we proceed as follows: Let the maximum number of coolings to which we intend to subject the brick be designated C. Then a brick may be considered to have failed when it has lost $\frac{100\%}{C}$ of its initial weight. Thus if C is taken as 5 we shall assume the brick has failed when it has lost $\frac{100}{5} = 20\%$ of its weight. If we select 10 coolings then the brick is considered to have failed when it has lost 10% of its weight. If we assume the brick has failed 100% when it loses $\frac{100\%}{C}$ of its weight after the first cooling we will have the expression

$$100 = \frac{100}{C} \times (C-T) + \frac{10}{C} \times W,$$

where W = loss in weight = C at complete failure, and if we assume that the brick has failed 0% when it has lost none of its initial weight after C coolings, we have

$$0 = \frac{100}{C} \times (C-C) + \frac{10}{C} \times W$$

and the expression

$$S = \frac{100}{C} \times (C - T) + \frac{10}{C} \times W$$

shows the percentage failure. The weights z_1 z_2 z_3 to be assigned Δc, Δp and Δs may be most easily determined after the results from the test brick have been given.

V. Fabrication of Carborundum Brick

Whenever sufficient clay is added to carborundum so as to fill the voids and surround each particle with clay there will be no trouble experienced in pugging or moulding the mixture. However, when these conditions are not fulfilled trouble begins and continues to increase as the percentage of clay is diminished. In the case of carborundum and Grand View Fire Clay it is almost impossible to pug a mixture containing 5% less clay than the theoretical requirement, but with certain plastic fire clays mixtures containing considerable less than the theoretical amounts may be successfully pugged. The reasons for this are obvious.

The bricks tested and given in Table I were mixed, rotted, and so forth, together so as to insure the same treatment throughout their fabrication. Due to the high percentage of carborundum bricks 15 and 16 had to be built up while the others were moulded by an expert brick maker, and it is reasonably certain that they were all wedged alike.

Considerable trouble was experienced with bricks 15 and 16 by failing along the cleavage planes, and whenever a failure was due to these cleavage planes the result was discarded. This action was justified because there is a difference between a brick failing by a break down of the material itself, and one failing by improper

fabrication. To eliminate these cleavage planes great pressures are required.

The different bricks which were subjected to these tests are given in Table I. The test of deformation at high temperature was conducted upon bricks 5–8 inclusive, 21, 22, 24, 25 and 26. The slagging test was conducted upon bricks 1–16 inclusive, 26 and 27. The spalling test was conducted upon bricks 1, 5–9 inclusive, 13, 17–22 inclusive, 24–26 inclusive. In Table II, are given the various screen analyses of the carborundum used in the different mixtures. The second column of Table I designates which screen analysis was used.

TABLE I—MIXTURES OF CARBORUNDUM CLAY

No.	No. of screen analysis	PERCENTAGE Carborundum	Clay	Clay used
1	1	50	50	G. V. Fire Clay
2		60	40	
3		70	30	
4		80	20	
5	2	50	50	G. V. Fire Clay
6		60	40	
7		70	30	
8		80	20	
9	3	50	50	G. V. Fire Clay
10		60	40	
11		70	30	
12		80	20	
13	4	50	50	G. V. Fire Clay
14		60	40	
15		70	30	
16		80	20	
17	2	50	50	Illinois Kaolin Non-Selected
18		60	40	
19		70	30	
20		80	20	
21	2	50	50	Washed G. V. Fire Clay
22	2	65	35	Non-Selected 17.5% G. Clay 17.5%
23	5	45	55	G. V. Fire Clay
24	Old Bricks 70% Carb.	Crushed Bricks Coated with slag		Washed G. V. Fire Clay

	30% Clay			
	2	60	40	
25	Old Bricks	Crushed Bricks		Washed G. V. Fire Clay
	70% Carb.	with slag removed		
26	30% Clay	60	40	G. V. Fire Clay
		0	100	
27	2	70	30	Washed G. V. Fire Clay

TABLE II—SCREEN ANALYSIS

No. of screen analysis	Mesh		Per cent weight
1	On	14	.18
		20	2.54
		28	32.52
		35	25.19
		48	15.51
		65	14.23
		100	7.12
		120	2.54
			99.78
3	On	14	.32
		20	6.66
		28	23.80
		35	14.42
		48	8.29
		65	8.03
		100	4.64
		150	14.44
		200	7.53
	thru	200	11.72
			99.85

No. of screen analysis	Mesh		Per cent weight
2	On	14	.12
		20	3.22
		28	29.19
		35	21.19
		48	12.59
		65	12.34
		100	7.06
		150	6.17
		200	2.68
	thru	200	4.98
			99.54
4	On	150	43.3
		200	22.2
	thru	200	34.5
			100.0
5	On	14	.08
		20	2.53
		28	17.30
		35	16.82
		48	13.84
		65	16.00
		100	20.00
		150	10.77
		200	2.94
			101.28

VI. Results Obtained from Test Brick

9. Decrease in Resistance to Deformation at High Temperatures.—The decrease in resistance to deformation at high temperatures are given in Table III. From this table it is perfectly obvious that the greater the percentage of carborundum the greater is the resistance to this deformation. The failure of bricks

7 and 8 was due to spalling along the cleavage planes. In the 3 failures recorded the bricks split in two lengthwise through the center. These failures as mentioned before were due to the method employed in making the bricks, and could probably be eliminated by making them under great pressure.

TABLE III

No.	Per cent linear compression	No.	Per cent linear compression
5	1.6	21	1.92
5	3.0	21	1.75
5	2.2	22	2.42
6	1.00	22	2.65
6	1.51	22	2.44
6	2.01	24	failed
7	failed	24	7.26
7	failed	24	failed
7	.96	25	failed
8	.86	25	failed
8	failed	26	7.6
21	1.8	26	10.1
		26	12.3

The results of the deformation test on bricks 5–8 inclusive, and 26 are shown graphically in Fig. 3. This curve represents the resistance offered to the linear compression of the bricks and may be expressed in terms of the per cent carborundum as follows:

$$R = 0.03775\ (80-C)^2 + .86.$$

R = The effect of linear compression.

$\frac{K'}{R}$ = life.

C = per cent carborundum.

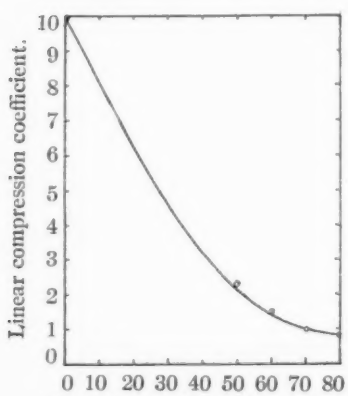

FIG. 3.

From this curve it is evident that where great loads are to be sustained at high temperatures a high percentage of carborundum is desirable. Brick 21 which contains washed Grand View Fire Clay stood up in excellent shape. Brick

22 is also an excellent brick, its appearance after the test being much better than any other brick tested.

10. Slagging.—Table IV shows the effect of slagging upon different mixtures of carborundum and clay, together with different sizes of carborundum. There seems to be no general law followed except that the mixtures high in clay stand up a trifle better than those containing a great deal of carborundum.

TABLE IV—SLAGGING TEST ON MIXTURES OF CARBORUNDUM AND CLAY BRICKS

No. of brick tested	Brick no.	Average area penetration in square cm.
3	1	2.04
3	2	1.51
3	3	3.33
3	4	3.44
3	5	2.04
3	6	3.80
3	7	2.10
3	8	2.74
3	9	1.23
3	10	2.32
3	11	2.08
3	12	2.82
3	13	2.10
3	14	2.11
3	15	1.75
3	16	2.46
3	26	2.00
3	27	1.53

The results from the slagging test on bricks 5–8 inclusive, and 26 are shown graphically in Fig. 4. The penetrations were small and difficult to measure and for this reason there is considerable uncertainty about each point. It is very improbable that the law followed is indicated by the jagged line and for this reason the dotted line B was selected. This line is of the first degree and probably represents the results as close as they can be determined with the present method of making these measurements. These results were so different from what had been expected that it was thought advisable to make a further study of the action of slags upon carborundum. Only a brief summary will be considered here.

It was found that carborundum would resist the action of most slags better under reducing than oxidizing conditions. That slags high in lead would quickly oxidize the carbon and unite with the silicon, in fact, when 25 grams of carborundum was mixed with 50 grams of lead oxide and heated at 1350°C for 30 minutes a 12-gram lead button was obtained in the crucible. Slags high in iron and silica also destroyed carborundum. On the other hand, slags high in silica and low in lead, iron and lime had practically no effect upon the carborundum.

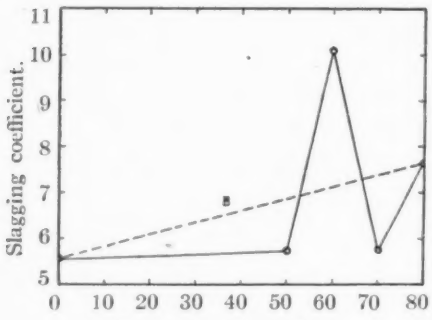

FIG. 4.

11. Spalling.—The results from the spalling test are given in Table V. In Fig. 5 the results for the various mixtures of carborundum (No. 2 screen analysis) and Grand View Fire Clay are shown graphically and also brick 26.

Here an attempt was made to test bricks which were alike in every respect except for the different percentages of carborundum used in the mixtures. It is obvious from this curve that up to a certain point the additions of small percentages of carborundum greatly decreases the rate of spalling. As more carborundum is added the change is less great and at last a point is reached where the addition of more carborundum

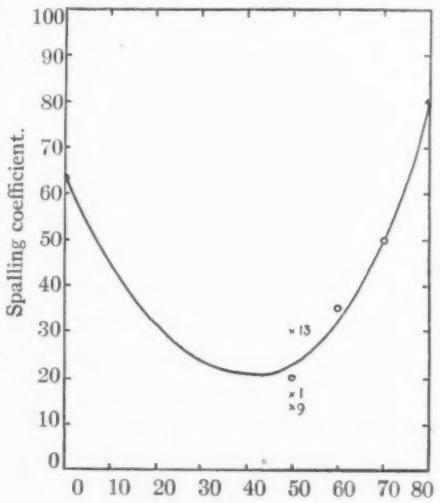

FIG. 5.

TABLE V—EFFECTS OF QUENCHING

No.	Temp. of fur. °C	Number of quenching	No effect	Small cracks	Large cracks	Failed
1	1350	8	1–2–3–4–5–6	....	7	8
1	1350	10	1–2	3–4–5–6–7–8–9	....	10
1	1350	10	1	2–3–4–5–6–7–8–9	....	10
5	1350	9	1–2	3–4–5–6	7–8	9
5	1350	10	1–2	3–4–5–6–7	8–9	10
5	1350	8	1–2	3–4–5–6	7	8
6	1350	9	1–2	3–4–5–6–7	8	9
6	1350	6	....	1–2–3–4	5	6
7	1350	6	....	1–2–3–4	5	6
7	1350	3	1	....	2	3
7	1350	9	....	1–2–3–4–5–6	7–8	9
8	1350	3	....	1	2	3
8	1350	1	....	....	....	1
8	1350	5	....	1–2	3–4	5
9	1350	7	....	1	2–3–4–5–6	7
9	1350	10	....	1–2–3–4–5–6–7–8–10	....	..
9	1350	10	....	1–2–3–4–5–6–7–8–10	....	..
13	1350	9	....	1–2–3–4–5	6–7–8	9
13	1350	9	....	1–2	3–4–5–6–7–8	9
13	1350	6	....	1–2–3–4–5	....	6
17	1350	5	....	1–2	3–4	5
18	1350	10	1–2	3–4–5–6	7–8–9	10
19	1350	9	1–2–3–4–5	6–7	8	9
20	1350	10	1–2–3–4–5–6	7–8–9–10	....	..
21	1350	10	1	2–3	4–5–6–7–10	..
21	1350	10	1	2–3	4–5–6–7–10	..
22	1350	10	1–2–3–4	5–6–7–8–9–10	....	..
22	1350	10	1–2–3–4	5–6–7–8–9–10	....	..
22	1350	10	1–2–3–4	5–6–7–8–9–10	....	..
24	1350	10	1–2–3	4–5–6	7–8–9–10	..
24	1350	10	1–2–3	4–5–6	7–8–9–10	..
25	1350	8	1–2	3–4–5–6–7	....	8
25	1350	10	1–2–3	4–5–6–7	8–9	10
26	1350	4	1	2	3	4
26	1350	6	....	....	1–2–3–4–5	6
26	1350	4	....	....	1–2–3	4

becomes a detriment and increases the spalling. This curve represents the resistance offered to the spalling action of the various bricks and is expressed by the equation:

$$R = 5(.025\ C)^4 + \frac{80 - C}{1.35 + .03 \times C}$$

where R = effect of spalling action, K = a constant, C = % carborundum.

The carborundum from the No. 2 screen analysis represents the regular proportion of sizes received and is the only one on which a spalling test was made upon a series of different mixtures. The spalling tests were also run upon bricks 1, 9, 13 and are shown in Fig. 5. From this test it is seen that the material should contain a little more fines so as to conform to screen analysis No. 3. (See point 9.) Point 1 represents the coarse material which apparently resists spalling better than brick 13 which contains all the fine material. (Screen analysis No. 4.) Referring to bricks 17–20 inclusive, we see that in the case of Illinois kaolin 50% carborundum is not sufficient while 60, 70 and 80% is much better. Brick 20 which contains 80% carborundum stood up best in these tests.

Only one brick of the various mixtures of Illinois kaolin and carborundum were tested, and for this reason very little weight can be given to any particular results.

Having tested our brick and obtained Δc, Δp and Δs we are now ready to determine z_1, z_2 and z_3. If the life of a carborundum brick is greater than that of a clay brick it must be due to a difference in their properties. Thus if the clay and carborundum bricks each resist slagging equally well we could not say that the superiority of the carborundum brick was due to its resistance to slagging. But on the other hand, if the difference between their linear compressions was great, then this must be a very important factor in increasing the life, and the weight assigned to linear compression should be a function of the ratio of compression between a carborundum and a clay brick. Since the linear compression of the carborundum brick varies as the second power of the per cent carborundum present, it is only reasonable to weight it as the square of the ratio between a clay brick and a clay carborundum brick. In the same manner the weight assigned to the spalling tests was taken as the ratio of the spalling tests raised to the fourth power. The weight assigned to the slagging test was taken as the ratio of the two to the first power.

Having determined the method of weighting these different results the next step was to decide which mixture of carborundum should be used in this ratio. The most logical one to use is that

one which will bring out most strongly the properties which characterize a carborundum brick. For this reason a brick containing the proper proportion of clay from a theoretical standpoint was used. According to the void test it was found that 68% carborundum was required. To determine the action of a brick containing 68% carborundum we shall refer to Figs. 3, 4 and 5.

Fig. 3. We have $\Delta c = 1.02$ Linear compression for brick containing 68% carborundum.

$\Delta c = 10$ Linear compression for brick containing 0% carborundum.

Fig. 4. We have $\Delta p = 7.3$ Slagging test for brick containing 68% carborundum.

$\Delta p = 5.56$ Slagging test for brick containing 0% carborundum.

Fig. 5. We have $\Delta s = 45$ Spalling test for brick containing 68% carborundum.

$\Delta s = 63$ Spalling test for brick containing 0% carborundum.

Forming the above ratios we have:

$$\left(\frac{63}{45}\right)^4 = 3.84$$

$$\left(\frac{10}{1.02}\right)^2 = 96$$

$$\frac{5.56}{7.3} = .762$$

Reducing these to whole numbers by dividing each factor by the smallest one (0.762) and taking the closest to 5 which is as close as the results warrant, we have: Weight for Spalling Test, 5 or 5, Linear Compression Test, 126 or 125, Slagging Test, 1 or 1, so that our formula becomes for these three destructive agents,

$$L = \frac{K'}{125.\,\Delta s + 5.\,\Delta c + \Delta p}$$

Having now determined numerical values for all of our unknowns we are ready to calculate the predicted life of the carborundum bricks. According to the operating report the life of the clay bricks in this furnace was 151 days. Referring to Figs. 3, 4 and 5, we have:

$$\text{Life of clay brick} = \frac{K'}{25 \times 10 + 5 \times 63 + 5.6} = \frac{237220}{1571} = 151 \text{ days}$$

and for the carborundum bricks we have

$$\text{Life } \frac{50}{50} \text{ brick} = \frac{237220}{125 \times 2.3 + 5 \times 20 + 7} = 600 \text{ days.}$$

$$\text{Life } \frac{60}{40} \text{ brick} = \frac{237220}{125 \times 1.52 + 5 \times 35 + 7} = 640 \text{ days.}$$

$$\text{Life } \frac{70}{30} \text{ brick} = \frac{237220}{125 \times 0.96 + 5 \times 50 + 7} = 629 \text{ days.}$$

$$\text{Life } \frac{80}{20} \text{ brick} = \frac{237220}{125 \times 0.86 + 5 \times 80 + 8} = 459 \text{ days.}$$

Curve (*B*) Fig. 6 shows these values plotted. Curve (*A*) shows the actual life of these bricks in Furnace No. 25. According to the theoretical curve the increase in life is very small after 50% car-

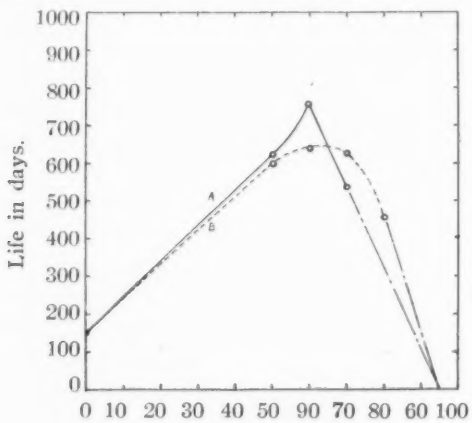

FIG. 6.

A.—Curve showing life of bricks in furnace #25.
B.—Curve showing life of bricks as calculated.

borundum has been added and decreases very rapidly after the addition of 65%. In curve (*A*), the bricks containing 60% carborundum show a much greater life than any other mix, but it

seems very improbable that this great life will be maintained over a longer period. It may be well to note here that the mixtures used in the furnace were taken from curve (B) and that curve (A) is really a check on the information given in this report.

As mentioned previously the abrasive action was not considered in calculating the life of these brick. If it had it is apparent that the calculated values would have been greater, thus making the two curves practically identical.

When this expression was developed and the predicted life calculated for the various mixtures it was hardly expected that the true values would check out as closely as they did. It was hoped however that the curve would show the relative value of each brick, so that an approximation to the most suitable mixture could be obtained under operating conditions. It is apparent that these expectations were realized. Brick No. 9 stood up best in the spalling test on mixtures of carborundum and Grand View Fire Clay, and while its screen analysis does not exactly conform to that given in problem No. 4 of this paper it approaches nearer to it than the other three.

VII. Theoretical Explanation for the Physical Properties of Carborundum Bricks

12. The results from the spalling test indicate that the addition of a certain amount of carborundum reduces the spalling, while if too much is added the spalling is increased. This may be accounted for as follows: Let us pass two parallel planes, AB and CD (see Fig. 7), through a refractory material and let the distance between these two planes be Δs. Let us also assume that heat is flowing from plane AB to the plane CD. Then the temperature of the face AB must be greater than CD by Δt. If we denote the coefficient of expansion of the mixture by e, then the face AB, is longer than CD by the amount $e \times \Delta t$ and the increased length per unit is $e \times \frac{\Delta t}{\Delta s} = e$ multiplied by the (temperature gradient).

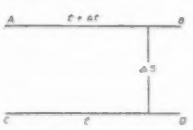

FIG. 7.

If we multiply this by some constant K we may change this

increase in length to pounds pressure per unit area set up in the clay. When the strain set up is less than the tensile strength of the mixture we have no cracking, when greater than the tensile strength we have cracking. This may be expressed more concisely in the form

$$K.e.\frac{\Delta t}{\Delta s} - T = Y$$

when Y is $-$ we have no cracking; when Y is $+$ we have cracking. (The coefficient of expansion e, the temperature gradient $\frac{\Delta t}{\Delta s}$, and the tensile strength T) are all functions of the quantity of carborundum in the mixture, the physical characteristics of the clay, the wedging of the mixture in fabricating the brick, and the temperature under which the refractory is working.

Fig. 1 shows the tensile strength of different mixtures of carborundum and Grand View Fire Clay. It will be noted here that the spalling is least when the tensile strength is nearly a maximum. In case of Illinois kaolin[1] the tensile strength is much greater than that of Grand View Fire Clay, and the maximum tensile strength is obtained with a higher percentage of carborundum.

We know that as the ratio of carborundum to clay is increased $e \times \frac{\Delta t}{\Delta s}$ is diminished. In the case of Illinois kaolin T is a maximum when the percentage of carborundum is high, so that we would predict that a higher percentage of carborundum is required than with Grand View Fire Clay. This was borne out by Brick 20 in the test.

From the equation $Ke.\frac{\Delta t}{\Delta s} - T = Y$, we may draw the following conclusions: (*a*) The coefficient of expansion of the mixture should be made as small as possible. With most clays this can be done by increasing the percentage of carborundum; (*b*) The temperature gradient $\frac{\Delta t}{\Delta s}$ is a function of the percentage of carborundum present, and decreases as the percentage of carbo-

[1] The curve for Illinois kaolin is not shown.

rundum is increased; (*c*) K is a constant independent of e or $\frac{\Delta t}{\Delta s}$. For this reason it is desirable to make the product $e.\frac{\Delta t}{\Delta s}$ as small as possible and this is done by making the percentage of carborundum great; (*d*) T, however increases until a certain amount of carborundum has been added and then decreases very rapidly. The mixture of carborundum and clay which will withstand the changes in temperature to the best advantage is that which will make Y a minimum and is shown graphically in Fig. 5 for Grand View Fire Clay.

From these conclusions it is quite evident that the resistance offered to spalling by any mixture of clay and carborundum depends upon its coefficient of expansion, thermal conductivity and tensile strength, and that if two clays have the same coefficient of expansion, the same thermal conductivity, and are mixed with equal percentages of carborundum, the one with the greater tensile strength will spall the least. Other comparisons are obvious. From this it is evident that carborundum decreases the spalling action by increasing the tensile strength, increasing the thermal conductivity and decreasing the coefficient of expansion of the mixture.

We are now ready to consider why it is so important to have suitable mixtures of various sizes. As an exaggerated case let us consider a mixture of very coarse material containing very little fines (Fig. 8) in which the voids are filled with clay. Let a = the coefficient of expansion of the carborundum; b = the coefficient of expansion of the clay. L_0 = distance between two arbitrary planes P and Q. $\Delta L_0 = \Sigma e$ where e_i represents the width of the layers of clay separating each carborundum particle along the line EF. $\Delta C_0 = \Sigma s$ where s_i represents the width of any particle of carborundum along the line GH. When $t = 0$ we have

$$(L_0 - \Delta L_0)(1 + at_0) + \Delta L_0(1 + bt_0) - (L_0 - \Delta c_0)(1 + bt_0) = 0$$
$$\text{or } (L_0 - \Delta L_0 - \Delta C_0)(a - b)t_0 = 0$$

and there is no strain between the two surfaces EF and GH. If now the temperature is raised to t_1, we have

$$(L_0 - \Delta L_0 - \Delta C_0)(a - b)t_1 = z \neq 0 \text{ if } a \neq b$$

so that a strain will be set up between the two planes which equals $\frac{kz}{\Delta s}$ pounds per unit area. When $\frac{kz}{\Delta s} > T$ the brick will crack. At high temperatures the clay becomes more or less plastic and the particles will so adjust themselves that the strain is less than that expressed by the formula. To adjust themselves the particles along the line EF must move relative to those along GH so that we have a sliding action going on within the brick. This movement of the particles is as undesirable as the strain.

If the voids in Fig. 8 are filled with carborundum the difference between the 2 terms in the above expression becomes less for any temperature t, and if the sizes of the particles of carborundum are so selected that they fill the voids the above expression will become very nearly equal to zero, and will equal zero when EF and GH have the same amount of clay and carborundum.

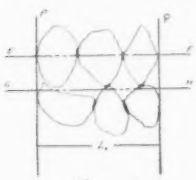

FIG. 8.

The quantity of heat transmitted from the surface FH to the surface GH will be greatest when the voids are filled with carborundum, so that from a theoretical standpoint the best results are obtained when the sizes are mixed so as to produce a minimum of voids. These conclusions have been borne out by the test brick and mentioned elsewhere.

From a consideration of Fig. 3 it is quite evident that the linear compression varies as the second power of the percentage of carborundum present. This may be readily explained as follows: Let us consider a clay brick in which both the grog and binding material have approximately the same softening point. If now a load is applied to the brick linear compression will take place. Both the particles of clay and grog will flatten out in proportion to the percentage of compression. Let us now replace the grog with carborundum. As the temperature is raised the clay will soften as before, but the carborundum remains rigid. In order for linear compression to take place the clay must now spread out around the particles of carborundum. This causes a much greater movement of the clay for a given compression of the brick and of course the rate of compression must be much slower. Since the movement of the clay around the carborundum is in a plane

we should expect it to vary as a function of the second degree which is borne out by the curve. Much trouble was experienced in testing the bricks containing considerable carborundum. This was due to the fact that the bonding strength was so low that the horizontal strains set up in the bricks caused it to rupture. Most of the trouble found in the 80–20 bricks would have been eliminated if better facilities could be had for fabricating them. It simply points out the fact, however, that the addition of too much carborundum makes difficulties which can not be overcome.

The results from the slagging test do not show a great deal of variation between clay bricks and clay carborundum bricks. Not only was this borne out by the test bricks but it has been found true in practice. In fact, in many cases the clay bricks have proven superior to the carborundum bricks from the standpoint of slagging.

Unless the slagging action is extremely great, however, carborundum is an excellent body for bricks where these physical destructive agents are severe. The fact that they resist abrasion, spalling, and deformation are the main reasons for their increased life in ordinary furnace work.

VIII. General Conclusions

(*a*) The various sizes of carborundum should be so proportioned that we have a maximum amount of coarse material with a minimum of fines, but sufficient fines must be added to fill the voids of the preceding coarser sizes. To realize this practically the dimensions of the finer sizes must approach zero as the voids become smaller and smaller. Therefore these conditions can only be approximately approached.

(*b*) The percentage of clay which should be added to the carborundum to fill the voids will depend upon the ratio of the sizes of the carborundum particles.

(*c*) Other things being equal the tensile strength of any mixture of carborundum and clay is proportional to the bonding power of the clay. When different percentages of carborundum and clay are mixed together the tensile strength increases rapidly at first, then remains practically constant, and finally decreases

very rapidly. The proper percentage of carborundum to use in any mixture to obtain the maximum tensile strength will depend upon the physical characteristics of the clay.

(*d*) When sufficient clay is added to carborundum to fill the voids and surround each particle with carborundum there will be no trouble in pugging or moulding the mixture. When these conditions are not fulfilled trouble begins and increases as the percentage of clay is diminished.

(*e*) The linear compression varies as the second power of the percentage of carborundum present, so that where bricks are to be subjected to great pressures the percentage of carborundum should be as high as possible.

(*f*) Carborundum will resist the action of most slags better under reducing than oxidizing conditions. It will not resist slags high in iron, lead or lime, but will resist those high in silica.

(*g*) The length of time a brick will resist spalling depends upon the percentage of carborundum in the brick, the tensile strength, coefficient of expansion, and thermal conductivity of the clay.

(*h*) Each bond clay presents a different problem and the proportions to use can only be determined by trial.

(*i*) The formula shows that a good bond clay should have the following properties: (1) High tensile strength, (2) high softening point, (3) low coefficient of expansion, (4) high thermal conductivity, and that a good body should have (1) rigidity at high temperatures, (2) low coefficient of expansion, (3) high thermal conductivity.

(*j*) And finally, if the refractories are to be used where the physical destructive forces are great (spalling, compression, abrasion, etc.) and the chemical forces small, carborundum will make an excellent grog. If the slags which come in contact with the refractories are high in silica carborundum may still be used. If the slags are high in iron, lead and lime and occur in great amounts, then carborundum should not be used.

THE TESTING OF SILICA BRICK

By K. H. Endell[1]

ABSTRACT

The Steger Load Test Apparatus.—Pressure was applied, in a granular-carbon resistance furnace, to the small test cylinders by means of a hollow carborundum rod. The temperature was read with an optical pyrometer sighted through this hollow pressure rod. The volume changes were indicated by a pointer and scale and recorded by means of a rotating drum. (See Fig. 1.)

Estimation of Quartz and Cristobalite in the Finished Brick.—The areas occupied by each type of crystal on the photomicrograph were determined with the aid of a transparent cross-section grating.

Suggested Specifications for A1 Silica Brick.—Their specific gravity not greater than 2.38; not more than 2% permanent linear expansion after heating to 1600°C in one and one-half hours, and holding at that temperature for one-half hour; the amount of quartz (and silicates) as determined by the grating method applied to photomicrograph should not exceed 15%.

Silica brick are assuming a position of ever-increasing importance among refractory materials. The greater value of silica brick as compared with fire-clay brick in resistance to high temperatures under load conditions and as regards their heat conductance is generally admitted. Silica brick are being used in ever-increasing numbers not only in steel furnaces, but also in coke ovens and for segments in the making of gas retorts.

Consonant with their great economic value for technical purposes, scientific investigations, during the last few years, have dealt with the determination of the properties of silica brick. Especially in the United States of America contributions of high value have been published on this subject, among others by Kenneth Seaver, J. Spotts McDowell, A. V. Bleininger, D. W. Ross, H. Insley and A. Klein, R. J. Montgomery and L. R. Office, and F. A. Harvey and E. N. McGee.

But in other countries also many experimental tests have been made and a great deal of research work on silica brick has been going on. Proper mixing of the raw materials and a sufficiently

[1] Received February 2, 1922.

long firing period are essential to the utilizability of silica brick. In Germany, where the conditions are best know to me, quite a different class of quartzite is used than in America. Some brief comparative tests made by me with German and American quartzites were published recently in the *Journal.*[1] German tertiary quartzites, so-called erratic-block quartzites, mostly show under the microscope, in a finely crystallized basal cement, peripherally corroded quartz crystals, which increase greatly in volume in the "first fire" up to Seger Cone 14. The American silurian and devonian quartzites on their part show in thin sections under the microscope, closely packed grains of quartz, which increase far less in volume during the first stage of heating. But as a maximum of transformation in the initial stage of burning is a consummation highly to be desired, brick of American quartzite demand treatment either at considerably higher temperatures or for a much longer period than the German erratic-block quartzite. The utilization of the more favorable tertiary quartzites of Germany, therefore gives, as compared with American quartzites, a saving of coal.

A useful schedule of silica brick tests in the laboratory was drawn up in 1918 by R. J. Montgomery and L. R. Office (as well as other speakers who joined in the discussion) and in 1921 by F. A. Harvey and E. N. McGee. For a period of ten years I have been engaged in examining the polymorphic structure of silica and in studying silica brick and that not only from a physico-chemical and mineralogical point of view, but also from the standpoint of the technique of practical testing.

Especially during the last few years I have tested a great number of silica brick in various connections. My researches were in the main confined to German silica brick, made partly by the factories of refractory materials attached to some great German steel works, supplying only the direct needs of those works, or by factories producing refractory materials for the market.

For purposes of comparison I submitted some American, English and Swedish silica brick to comparative tests.

My experiments covered the following properties:

[1] *This Jour.*, **4**, 953(1921).

1. Specific gravity (determined volumetrically in the specific gravity bottle).

2. Determination of the temperature of rupture and the softening temperature under a load of 1 kg. per sq. cm. (equivalent to about 15 lbs. per sq. in.).

3. Linear expansion after repeated heating up to 1600°C.

4. Microstructure, especially the proportion of quartz to cristobalite and tridymite.

The chemical analysis, the temperature of fusion expressed in Seger cones, the porosity, and the mechanical strength when cold, I do not consider of great importance.

The following details may be given concerning the special tests:

1. **Specific Gravity.**—All tests were made on *finely* powdered material in small pycnometers of 3 ccm. capacity using the boiling procedure. Volumetric tests by the boiling method have frequently led to too low results, thereby creating a false impression of a degree of transformation not warranted by the facts. In some 100 determinations, for the most part repeated several times, the difference in check determinations involved only the second decimal.

2. **Determination of the Temperature of Rupture or the Softening Temperature under Load Conditions.**—The tests were carried out partly with the lever-press previously described[1] and partly by the method of Dr. W. Steger, details of which are given in Fig. 1. By the first method the temperature of rupture was determined; by the second the softening temperature. The temperature measurement being quite different, a comparison of the absolute temperature range is not admissible.

To shorten the apparatus a one-armed lever was used. The load-bearing wagon is detachable so that it can be separated from the electric furnace, thus allowing the latter to be worked alone. The changes of volume of the fire brick cylinder are indicated on a scale. Recording is also possible by means of a rotating drum. The accurate measurement of the temperature is carried out with the aid of the Holborn-Kurlbaum pyrometer by means of the axis of the upper pressure rod through the center

[1] K. Endell, *Stahl ü Eisen*, **41**, 6–9(1921); cf. *This Jour.*, **4**, 417(1921).

of which a perforation of 15 mm. in diameter passes. The apparatus that records the change in volume is constructed so as to admit a variation in the range of the pointer by changing the lever ratio. The load was 1 kg. per sq. cm. which is a very close approximation to practical conditions. Occasionally a load of 2 kgs. per sq. cm. was applied without any material alteration of the results. Hence it is possible to compare directly the results with those obtained in America, as these are mostly ob-

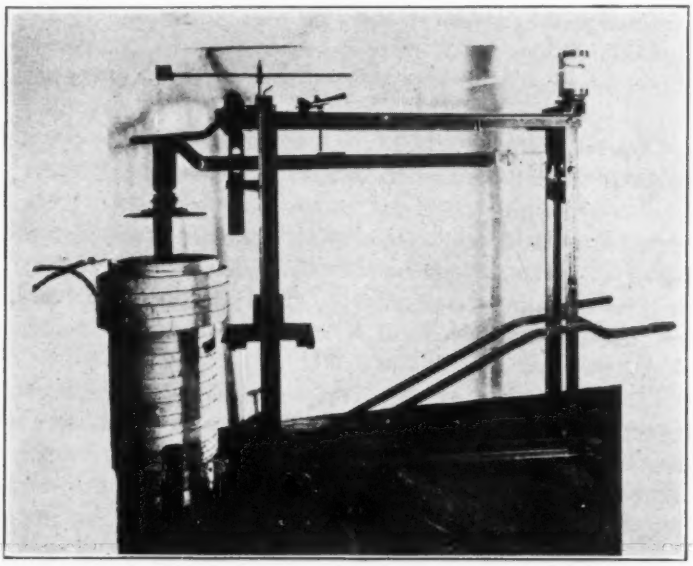

FIG. 1.—Dr. Steger's lever press with the carbon resistance furnace and the prism of the optical pyrometer.

tained with 1.7 kg. per sq. cm. which corresponds to 25 lbs. per sq. in. The test cylinders were uniformly made in the German Staatliches Materialprüfungsamt by cutting them, with a diamond drill cylinder 50 mm. in diameter and 50 mm. high, out of standard burnt brick ready for use. The ends of the cylinders were ground down and polished off smooth to the required height. I am quite aware, however, that this procedure results in destroying the outer integument of the brick which is of such great

value to all ceramic substances. To compensate for this, however, I had a uniform testing material. At times also cylinders of the same size were made in the laboratory in soft steel rings out of a mixture of silica raw material under a pressure of 300 kgs. per sq. cm. These were then burnt at a temperature of 1450°C in the large porcelain furnace.

As the method worked out by the American Society for Testing Materials, by which after a fixed period of preheating a load of 1.7 kg. per sq. cm. acts on silica brick for a period of one and a half hours at 1500°C or 4 hours at 1400°C, produces no values that will bear comparison—for most bricks can stand so comparatively light a test—for a crucial test I adopted the determination of the temperature of rupture or softening under the given conditions with a load of 1 kg. per sq. cm. In this connection it should not be forgotten that the testing of a cylinder which is heated without any lateral support whatsoever takes place under far more severe conditions than when the silica brick in the wall is attacked only from one side by the direct influence of the heat. However, that may be, it is possible to establish comparative values. The determination of the temperature of rupture or softening under load conditions renders the determination of the SiO_2 content and the melting temperature expressed in Seger cones superfluous.

3. Determination of the Linear Expansion after Repeated Heating up to 1600°C.—I quite agree with Mr. R. M. Howe[1] that it is of paramount importance to find out the degree of expansion after repeated firing. Heating as in the U. S. A. for 4 hours at a temperature of 1400°C or for one and a half hours at 1500°C seems to be insufficient. In steel furnaces silica brick are subjected to a temperature of at least 1600°C and coke ovens too, under the forced firing of today are often operated at a temperature exceeding 1500°. To raise the temperature for testing up to 1600° seemed, therefore, the better way.

The experiment was conducted under the following conditions. The test cylinders (described in paragraph 3) of 50 mm. height and diameter were heated in granular carbon resistance furnaces for about one hour and a half up to 1600°C. This temperature

[1] *This Jour.*, **1**, 348 (1918).

was kept constant for half an hour before cooling. Later on the electric muffle furnace pictured below was made use of. The carborundum muffle, embedded in granular carbon has a working space which admits of uniform heating and permits the use of standard bricks 6 x 12 x 25 cm. With the test cylinders it was possible to heat six at a time. With 120 volts and 100 amperes 1600 °C was reached in an hour and a half. The linear expansion of the test cylinders heated up to 1600 °C was measured with a sliding gauge after cooling. The corresponding determination

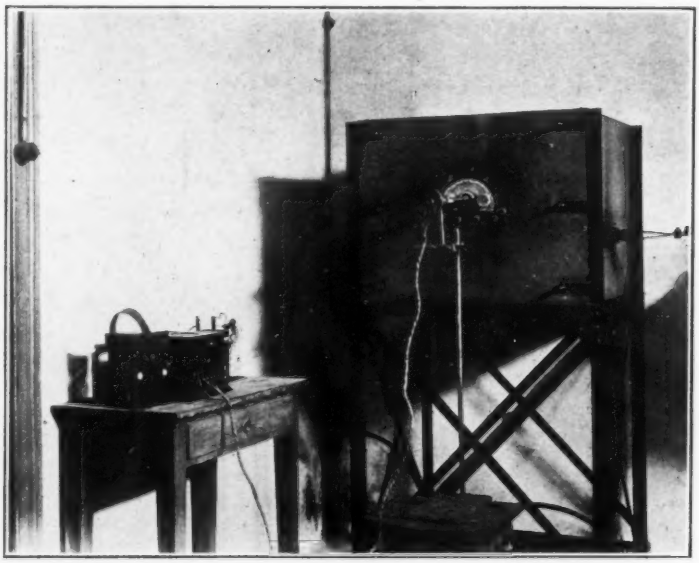

FIG. 2.—Electrically heated muffle furnace. Designed by the Didier Fire Brick Works of Stettin.

of the specific gravities in most cases gave a result of 2.32-2.35. Thus the maximum expansion was almost reached. The examination of the microstructure in thin sections showed an increase in amount and an augmentation of grain size of cristobalite, which according to the experiments of the Geophysical Laboratory is the stable form of SiO_2 above 1470 °C.

4. Microstructure.—All students of the behavior of silica brick have pointed out that the polymorphic condition of silica

at high temperatures is of prime importance. The important thing is to determine the relative amounts of quartz, cristobalite and tridymite as exactly as possible. For this reason C. H. Warren and J. Spotts McDowell, and H. Insley and A. A. Klein employed the method of determining the indices of refraction of the different minerals in the brick. This method is difficult to apply in a technical laboratory. The results of this method of investigation are controlled by the values of the specific gravity and the increases in volume on heating to 1600°C. For the technical testing of silica brick it seems sufficient, by means of a more simple method, to determine in the photomicrographs the amount of quartz and silicates the grains of which have a higher birefringence and a higher index of refraction.

This was done by placing a grating of transparent paper ruled in 1 millimetre squares on the photomicrographs which were usually magnified a hundred times. The squares containing quartz and silicate crystals were pricked with a needle and counted. The remainder is usually cristobalite, while tridymite in finished silica brick is represented in most cases by less than 5 per cent. The tridymite was estimated and the cristobalite determined by difference. I consider this method to be exact within about 2 per cent.

Conclusions

The following conclusions may be drawn from Tables I and II:

The correspondence between the values of true specific gravity, the subsequent increase in volume at 1600°C, and the amount of unaltered quartz in the completed brick are most striking. The lower the specific gravity and the smaller the subsequent increase in volume, the less quartz is to be seen in thin sections. A diagram of these conditions of correspondence as has been beautifully given by F. A. Harvey and E. N. McGee for linear expansion and specific gravity could not be made probably owing to the fact that the American test which involves heating for 4 hours up to 1400°C or the repeated firing in the industrial kilns marks the completion of a certain stage more nearly than heating at 1600°C for only half an hour. Be that as it may, the differences are evident. The comparison of the values also proves

TABLE I

PROPERTIES OF SILICA BRICK MADE BY GERMAN FACTORIES

No.		Specific gravity	LOAD TEST 1 kg. sq. cm. *a*. Temperature of rupture, (old lever press). *b*. Softening temperature (Dr. Steger's press) in °C	LINEAR EXPANSION after heating ½ hr. at 1600°C in %	MICROSTRUCTURE Content in % Quartz (plus silicates)	Cristobalite	Tridymite
1	A 1 Basic Open Hearth Furnace Type	2.40	*b* 1550°	3.3	28	70	ca 2
2		2.40	*b* 1550	3.5	23	75	ca 2
3		2.38	*b* 1540	2.8	25	72	ca 3
4		2.48	*b* 1555	3.3	29	70	ca 1
5		2.50		4.5	40	60	..
6		2.42	*b* 1520	3.2	16	82	ca 2
7		2.37	*b* 1525	2.2	14	82	ca 4
8		2.40	*b* 1530	3.4	22	78	..
9	By-Product Coke Oven Type	2.49	*b* 1470	4.5	30	70	..
10		2.48	*b* 1455	5.0	34	46	..
11		2.46	*a* 1620	3.8	35	65	..
12	Glass Furnace Type	2.47	*a* 1600	4.0	40	60	..

TABLE II

PROPERTIES OF SILICA BRICK

No.		Specific gravity	LOAD TEST 1 kg. sq. cm. *a*. Temperature of rupture (old lever press). *b*. Softening temperature (Dr. Steger's press) in °C	LINEAR EXPANSION after heating ½ hr. at 1600°C in %	MICROSTRUCTURE Content in % Quartz (plus silicates)	Cristobalite	Tridymite
13	Made by *German Steel Works* for private consumption A 1 Quality	2.38	*a* 1620°	1.4	13	82	<5
14		2.35	*a* 1655	0.4	16	80	ca4
15		2.33	*a* 1670	1.0	10	85	5
16	A 2 Quality	2.32	*a* 1620	0.8	13	82	5
17		2.36	*a* 1605	0.6	11	85	4
	U. S. A.						
18	Made from Medina Quartzite "Star"	2.34	*a* 1620 *b* 1535	0.5	14	81	5

19	Made from Barraboo Quartzite	2.33	.....	..	13	82	5
	England						
20	Made from English Silica Ganisters	2.40	*a* 1660	3.1	25	70	<5
21		2.40	*b* 1670	4.0	19	76	<5
	Sweden						
22	Made from Swedish Quartzite	2.39	*a* 1620	4.0	18	77	<5
23		2.34	*a* 1650	1.7	15	80	<5

that American silica brick, made of typical rock quartzites, show the same valuable properties as do German silica bricks made of the best erratic-block quartzites. As a matter of fact, therefore, the question of the nature of the quartzite raw material does not seem to be of prime importance, as long as, after proper mixing of the ingredients, the time of heating and the temperature of heating are, respectively, sufficiently long and high.

Among the different German products the brick made by the great German steel works themselves are, as may be proved, usually better than the trade products of refractory works. The reason for this may possibly be that the great steel works with factories of their own are makers and users at the same time and have no need for making an intermediary profit, as the refractory trade works must. The former are therefore able to use coal for firing purposes in more generous proportions and to fire longer and to higher temperatures than the latter.

In attempting to formulate certain *minimum requirements* from the figures given for the testing of silica brick, we arrive, on the basis of my experiments, at limiting values similar to those which Mr. D. W. Ross has already formulated from his experimental results.

In accordance with American usage, I should consider it advisable to make no distinction in the quality of the silica brick used for steel furnaces and those for by-product coke ovens. Such a distinction is still made in Germany, where very often, much to the detriment of the life of the coke oven plants, the ovens are still supplied with a No. 2 grade of silica brick. At most it is only in the case of silica brick for glass tanks that other qualities

and conditions may be demanded as with these the density is of greater value than a high temperature of rupture or softening.

In formulating the minimum requirements for finished silica brick I will, therefore, exclude silica brick for glassmaking purposes. On the basis of my experimental results I suggest the following specifications for A 1 silica brick:

1. That the pycnometrically determined specific gravity of the finely pulverized substance be at least 2.38.

2. That the temperature of rupture under load conditions of 1 kg. per sq. cm. measured according to the old method be at least 1620°C, and that the softening temperature under the same conditions according to the new Dr. Steger lever press method be at least 1520°C. I do not, however, believe that this test is necessary for silica brick.

3. That the testing of the linear expansion after heating $1^1/_2$ hours from 20° to 1600°C, the test being kept constant for half an hour at 1600°C according to the method adopted shall not produce a linear expansion of more than 2 per cent.

4. That on examination of the microstructure in a thin section the content of unchanged quartz (and silicates) determined by means of a grating shall not exceed 15 per cent. It is desirable that the tridymite content be at least 5 per cent.

I have the honor to offer these suggestions for discussion by the American Ceramic Society and should be glad if my experiments, together with those of American investigators, should lead to the formulation of uniform testing methods for silica brick.

TECHNISCHE HOCHSCHULE
CHARLOTTENBURG, GERMANY

DISCUSSION OF THE PAPER ON "TESTING OF SILICA BRICK" BY DR. KURD ENDELL PRESENTED AT THE ST. LOUIS MEETING OF THE AMERICAN CERAMIC SOCIETY

FRED A. HARVEY AND E. N. McGEE

This very carefully worked out paper has been especially interesting to us because it covers the same general ground as we have covered in our own tests during the past few years. We should like to discuss the following points. **1. Specific gravity.** In our work the apparent specific gravity has been the value more

frequently determined and is the value used in our published work. In this method the sample is boiled for an hour and a half under a vacuum of at least 20 inches of mercury, and we have found that the method yields very consistent results. This value is about .02 lower than the true specific gravity as determined by Dr. Endell. This fact must be born in mind in making comparisons. **2. Residual Linear Expansion.** In all of our tests for determining residual linear expansion the sample was heated very slowly to 1450°C and maintained at this temperature for 72 hours. Repeated tests at various lengths of time show that this time and temperature will reduce the specific gravity practically to its minimum value, thus bringing out practically all the residual linear expansion. It is American practise to heat clay brick for 5 hours at 1400°C to determine expansion or contraction, but we are not aware that anyone has used 4 hours at 1400°C to determine residual expansion in silica brick as assumed by Dr. Endell. This time and temperature certainly would not bring the brick to its final state. We doubt if Dr. Endell's rate of heating to 1600°C in $1^1/_2$ hours is slow enough to give consistent results on residual expansion even on the small samples which he used. Our own experience indicates that a much slower rate is necessary. The results in Dr. Endell's paper do not in general check well with the chart published by us. We have already tested two samples of English Silica Brick and three Australian silica brick. This is hardly a sufficient number to draw any definite conclusions. The results obtained on the Australian samples did not check up with any of our results on American brick. The apparent density appeared to be considerably lower than for American bricks for the same percentage of expansion as determined by the reheating test—72 hours at 1450°C. The English bricks, however, checked up better and it would appear that a larger number of results would show them to be in very good agreement. **3. Hot Crushing Strength.** The values of hot crushing strengths as determined on American bricks by A. S. T. M. method C–16–20 give considerably higher results than those given by Dr. Endell for German and American Silica Bricks.

We would be very much interested in subjecting some of the German Silica Bricks to our American Tests.

JOURNAL AMERICAN CERAMIC SOCIETY

Preparation of Abstracts

Every article in THIS JOURNAL is to be preceded by an abstract prepared by the author and submitted by him with the manuscript. The abstract is intended to serve as an aid to the reader by furnishing an index and brief summary or preliminary survey of the contents of the article; it should be suitable for reprinting in an abstract journal so as to make a reabstracting of the article unnecessary. The abstract should, therefore, **summarize all new information completely and precisely.** Furthermore, in order to enable a reader to tell at a glance what the article is about and to enable an efficient index of its subject matter to be readily prepared, the abstract should contain **a set of subtitles** which together form a **complete and precise** index of the information contained in the article. This requires at least one and often several subtitles even for a short abstract.

In the preparation of abstracts, authors should be guided by the following rules, which are illustrated by the abstracts in THIS JOURNAL for February and March, 1921.* The **new information** contained in an article should first be determined by a careful analysis; then the subtitles should be formulated; and finally the text should be written and checked.

Rules

1. **Material not new** need not be analyzed or described in detail; a valuable summary of a previous work, however, should be noted with a statement indicating its nature and scope.

2. **The subtitles should together include all the new information;** that is every measurement, observation, method, improvement, suggestion and theory which is presented by the author as new and of value in itself.

3. **Each subtitle should describe the corresponding information so precisely** that the chance of any investigator being misled into thinking the article contains the particular information he desires when it does not, or vice-versa, may be small Such a title as "A note on blue glass," for example, is evidently too indefinite a description of information regarding "Absorption spectra of glass containing various amounts of copper-cobalt and chromium-cobalt." General subtitles, such as "Purpose" and "Results" should not be employed as they do not help to describe the specific information given in the article.

4. **The text should summarize the authors' conclusions and should transcribe numerical results of general interest,** including those that might be looked for in a table of physical and chemical constants, with an indication of the accuracy of each. It should give all the information that anyone, not a specialist in the particular field involved, might care to have in his note book.

5. **The text should be divided into as many paragraphs as** there are distinct subjects concerning which information is given, but no more than necessary. All parts of subtitles may be scattered through the text but the subject of each paragraph, however short, must be indicated at the beginning.

6. **Complete sentences** should be used except in the case of subtitles. The abstract should be made as readable as the necessary brevity will permit.

7. The ms. of all abstracts must be typewritten and double or triple spaced.

* The rules were prepared by the Research Information Service of the National Research Council. The Society is indebted to Dr. G. S. Fulcher of the Corning Glass Works (formerly with the National Research Council) for the rules and the illustrative abstracts.

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Ross C. Purdy, Editor
Lord Hall, O. S. U., Columbus, Ohio

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General and Miscellaneous

1. Some general remarks for factory organization. ANON. *Sprech.*, **53,** 493(1920).

2. Air cracks in grog products. FISCHER. *Tonind. Ztg.*, **44,** 1270(1920).—These cracks are due to air trapped in the body.

3. An oil purifier. ANON. *Tonind. Ztg.*, **44,** 662(1920).—The impurities including water are removed from oil by centrifugal force.

4. "Osmo" clay (Westerwald). ANON. *Tonind. Ztg.*, **44,** 630(1920).—The compn. of the clay and the method of purifying it are described. It is remarkable in having a high alkali and low feldspar content.

5. The condition and prospects of the British ceramic industry. J. A. AUDLEY. *J. Soc. Chem. Ind.*, **40,** 21–22(1921). E. H. (*C. A.*

6. The Cottrell process of electrical precipitation. H. A. WINNE. *Gen. Elec. Rev.*, **24,** 910–21(1921); 13 illus.—History, theory and full detailed account of most modern app. and its operation. C. G. F. (*C. A.*)

7. Problems in heat economy (in Germany). RUMMEL. *Z. Ver. Zuckerind.*, **71,** 539–49(1921).—The principal present-day problems are: (1) The use of powdered coal (profitable only where a good grade with low ash can be obtained cheaply, and where special large furnaces are available); (2) the use of powdered semi-coke; (3) the use of coal gas; and (4) the use of steam storage tanks; these are now made with a capacity of up to 345 m.^{3} of water, into which the steam is blown at high pressure and released again as needed. By the use of these tanks a saving of 15% of coal has been effected.

F. W. ZERBAN (*C. A.*)

8. Liquid, colloidal and powdered fuels. ORMANDY. *Colliery Guardian*, **122,** 311–2(1921).—The use of oils too heavy or too impure for engine consumption is recommended for general industrial use. Difficulties of burning have been nearly overcome in Great Britain and the relative values of the fuels remain a financial problem only. C. C DAVIS (*C. A.*)

9. The use of pulverized coal. PAUL FRION. *Monit. papeterie française*, **52,** 327–8, 364–8, 409–11, 510–1, 578–9, 618–20, 681–4(1921).—A detailed analysis of the advantages and disadvantages of pulverized coal at the present time. A. P.-C. (*C. A.*)

10. Engineers for firing technique in the ceramic industry. R. CLAUSE. *Tonind. Ztg.*, **44,** 787(1920).—The writer emphasizes the importance of the field of heat engineering.

PATENTS

11. Mining and purifying clay. J. S. HIGHFIELD. U. S. 1,366,456, Jan. 25. A stream of H_2O is forced against a clay face, the resulting liquor is led to a collecting vessel and the liquor in the stream is returned against the clay face until a sufficient concn. is attained. The liquor is then passed to a settling plant, where a small amt. of an electrolyte such as Na_2CO_3 or Na silicate is added and after the liquor has been allowed to settle it is pumped to a treating plant for extg. clay from it by electrolytic treatment. (*C. A.*)

12. Bearing of vitrified shale. H. R. STRAIGHT. U. S. 1,360,244, Nov. 23.

Machine bearings are formed of natural shale by cutting it to the desired shape of the bearing, gradually heating it to the point of vitrification and then cooling. Bearings thus formed are stated to be suitable for use with steel shafts in adding machines or clocks. (*C. A.*)

13. "Artificial slate." E. FAHRIG. U. S. 1,362,563, Dec. 14. A mixt. adapted for making roofing tiles or tool handles is formed of powdered slate 41, SiO_2 11, S 15, "magnesite" (MgO?) 10, talc 9, kaolin 8, and sericite 6 parts, mixed with $AlCl_3$ or $MgCl_2$ soln. (*C. A.*)

Apparatus and Instruments

14. Measuring the gloss of paper; apparatus. L. R. INGERSOLL. *Optical Soc. of Amer.*, **5,** 213–17(1921).—The instrument measures the propn. of light which is polarized by reflection from the surface, as this is the portion regularly reflected. The scale of deg. of gloss is an arbitrary one, being the reading in degs. of the position of an analyzing nicol. Although the instrument gives the optical, as distinct from the mech. gloss it is found that the two are closely connected. Applications to *enamel* and *whiteware* surfaces are not discussed. (*Sci. Abs.*)

15. Water jet sand washers. ANON. *Tonind. Ztg.*, **44,** 1270(1920).—A description of the Korting app.

16. The current-temperature relation for different pyrometer filaments. W. E. FORSYTHE. *Frank. Inst. J.*, **191,** 838–39(1921).—A test of the current-temp. relation was made in the case of tungsten and carbon pyrometer filaments and the ratios of currents were found to be very nearly the same for the temp. range from 1828°K to 950°K if the filaments were long enough so that the cooling due to end losses was negligible. Hence a pyrometer lamp with a carbon filament is not superior to a tungsten lamp in openness of scale. (*Sci. Abs.*)

17. The exposition of apparatus for the control of combustion organized by the Office Central de Chauffe Rationelle (March 12–25, 1921). CH. BERTHELOT. *Rev. metal.*, **18,** 389–418(1921).—A detailed discussion, with many cuts, of some of the instruments displayed (recording manometers, gas meters, meters for liquids, steam, and coal, thermometers and pyrometers, gas analysis app., fuel calorimeters). The application of the data furnished by the instruments, and in some cases the theory of their operation, is discussed at length. A résumé is given of the work of the "Office central de chauffe rationelle." DONALD W. MACARDLE (*C. A.*)

18. A furnace temperature regulator. H. S. ROBERTS. Geophys. Lab. *J. Wash. Acad. Sci.*, **2,** 401–9(1921).—White and Adams' method (*C. A.*, **13,** 2304) of using furnace heating coil as a gigantic resistance thermometer in temp. regulation was followed with an attempt to substitute a better operating device. A galvanometer making direct elec. contacts with the boom is sensitive enough; two relays, one of them polarized, did the rest. Failure or sticking of the contacts gave trouble, which was avoided by putting in series with the galvanometer the secondary of a transformer whose primary current is

changed by each change in the relay current, thus giving a kick which throws the galvanometer boom away from the contact as soon as the relays are set. A lamp flasher in the primary circuit also gives occasional kicks in both directions, insuring against any lasting failure to either make or break of contact. The regulator holds its furnace coil resistance const. to an amt. corresponding to 0.1° for hrs., even with 6% variation in line voltage.

W P. WHITE (*C. A.*)

PATENTS

19. Analyzing gases. S. A. S. KROGH and P. H. PEDERSON. Brit. 169,130. May 10, 1920. Relates to app. for the automatic measurement of each of 2 or more constituents of a gas mixture, *e. g.*, CO_2 and CO in flue gases, etc. Two or more gas-analyzing units, each comprizing a "first" measuring vessel, an absorber, and a "second" measuring vessel, are connected in series, and the 2nd and subsequent "first" measuring vessels are adapted to restore the original vol. of the sample by the addition of air to the indrawn gas; direct readings in per cents and of reasonable accuracy are obtained. (*C. A.*)

20. Thermocouples, etc. W. C. HERAEUS GES. Brit. 168,977. June 9, 1920. Addition of 138,648(*C. A.*, **14**, 1806). Metals and alloys for thermoelec. purposes are melted and refined *in vacuo*, as desrcibed in the principal patent. The alloys used may be obtained from chemically pure metals. (*C. A.*)

Chemistry, Physics and Geology

21. Weldability of solid powders by pressure T. v. HAGEN. *Zeits. Elektrochem.*, **25**, 375–86(1919).—Expts. are made with a great number of pure inorg. substances (oxides, salts, sulphides, *quartz*, graphite), both hydrated and anhydrous, to ascertain whether they can be compressed to cohesive tablets or cylinders, and how appearance, hardness, and strength of the product depend upon the melting point, hardness gram size of mat., upon the pressure, nature of binding agent (mostly water) and other conditions. The mats. were powdered (25 meshes per sq. mm.) and subjected generally to a pressure of 500 kg./cm.², small cylinders (0.5 gm. or less) being formed; in special expts. the pressure was raised from 560 to 9800 kg./cm.² The crushing tests of the products were pushed up to 230 kg./cm.²; harder tablets were tested by the sclerometer. The mats. are distinguished as non-weldable, powdery, smooth, homogeneous, plastic. Soft mats. (hardness up to 1.5) are generally plastic with hardness 1.5 to 2.5 homogeneous or smooth. Fine grains cohere better than coarse grains. As the melting point rises, the weldability decreases. Oxides give powdery bodies of low strength. Quartz and barium do not cohere at all. The d. increase with pressures may be regular (kaolin up to 7000 kg./cm.²) or more rapid at first than later; homogeneous bodies soon reach a max. d. In general weldability and plasticity (depending upon the number of gliding planes) go together. (*Sci. Abs.*)

22. Viscosity measurements. O. FAUST. *Zeits. phys. Chem.*, **93**, 758–761 (1919).—In detg. the viscosity of highly-viscous materials by the method of Cochius, an air bubble is introduced into a vertical tube, about 50 cm. high

and the rate of ascension of the bubble is measured. In such tests the width of the tube is not stated, as a rule. F. shows that for fairly wide tubes (15 to 21 mm. diam.) the tube diam. should be, and is, of no influence, and that in such tubes the size of the bubble is also immaterial, provided the bubble be approx. cylindrical and not pointed. In narrow tubes slight discrepancies may arise, because the bubble diam. $2r_1$ is a little smaller than the tube diam. $2r$, so that $(r + r_1)$, a sum entering into the calculations, is not quite equal to $2r$.
(*Sci. Abs.*)

23. Systems of color standards. A. AMES, JR. *Optical Soc. of Am.*, **5,** 160–70(1921).—Devices for enabling the color of any object to be detd. may be based either on the use of a colorimeter or a standard composed of colored cards. The latter method is much simpler and is considered in this paper. Such a standard must satisfy requirements as regards arrangement, nomenclature, number, spacing and standardization. All colors may be defined in terms of *hue* (wave length), *chroma* (saturation), and *value* (brightness). Munsell has devised the most perfect representation of colors in terms of these factors. In arranging the system, it is preferable to keep the value constant with changing color and saturation. Accordingly, all colors of the same hue or wave length are arranged on one chart, and a series of charts is provided. In the Munsell system *hue* is designated by a letter, *value* by a number above a line *t* to the right of the letter, *chroma* by a number below this line. The author concludes that there should be 50–80 steps in hue, 70–100 in value, 35–50 in chroma giving a total of about 13,000 different cards for complete analysis. As regards spacing, the deg. of sepn. should be the same throughout the entire system. Standardization should be effected by calcg. the 3 constants for each card and obtaining the conditions with a colorimeter, the results being produced on cards. In conclusion the author discusses Redway's system, which is probably the most used today, but does not completely satisfy the conditions prescribed for a color-standard.
(*Sci. Abs.*)

24. Molecular heats at very high temperatures. H. v. WARTENBERG AND G. WITZEL. *Zeits. Elektrochem.*, **25,** 209–12(1919).—By burning in a bomb calorimeter Mg in the presence of a varying amt. of MgO the sp. ht. of MgO can be computed. The following results ($\pm$10–20%) for mol. ht. capacity (small cal.) at the abs. temps. indicated were obtained. MgO, 10.2, 415°; 14.5, 1683°. CaO, 11.6, 559°; 13, 1369°. Al_2O_3, 10.8, 230°; 29, 1308°.
ED.

25. Silicic acid as a medicine. ANON. *Tonind. Ztg.*, **44,** 431(1920).—See TRANS., **19,** Abs. 132 (1920).

26. Studies on sedimentation. P. RONA AND P. GYÖRGY. *Biochem. Zeit.*, **105,** 133(1920).—Non-electrolytes have marked influence on the sedn. velocity of kaolin.

27. Atomic grouping and the optical rotation of quartz and sodium chlorate. J. BECKENKAMP. *Zeits. anorg. Chem.*, **110,** 290–310(1920).—The author discusses chiefly *quartz*, *christobalite* and *tridymite* and the influence of temp.

on these modifications and on their twinning. The twins are either of the Dauphinée type (both crystals of a pair alike) or of the Brasilian type (the two crystals differing as the left and right). Referring particularly to Groth, Sohncke and W. H. Bragg, he conceives that the 3-point helix is due only to the introduction of oxygen and not characteristic of silicon. The spiral grouping of the layers at right angles to the intermediate axes goes together with a spiral arrangement for layers at right angles to the main axes. The silicon atoms form a rhombohedral lattice; the disposition of the oxygen atoms is such that the orientation of their valency directions is the same in horizontal and vertical layers. The silica molecule is probably double, with the 2 Si vertically above one another. In the right- and left-handed crystals

the molecules are enantiomorphs of one another. Heating favors twinning of the Dauphinée type, not of the Brasilian type; that indicates that the Si and O of the same molecule are more strongly linked and less easily displaced than 2 molecules are. (*Sci. Abs.*)

28. Heating-curve study of rapid low-temperature reactions: barium oxides. J. A. HEDVALL AND N. V. ZWEIGBERGK. *Zeits. anorg. Chem.*, **108** 119–36(1919).—Hedvall [*ibid.*, **104,** 163–68(1918)] had shown that while pure barium peroxide BaO_2 decomposed into oxide and oxygen at 800°, it liberates oxygen as low as 200° in the presence of silica. In the present paper it is shown that similar catalytic reactions take place in the presence of a great number of oxides (not only of acid character), and that there may be decomposition of the peroxide without formation of a compd. The expts. are made with masses of about 5 gm. in porcelain crucibles heated in gas furnaces, temps. being measured every 10 sec. by thermal couples. Of the oxides investigated, SnO, SnO_2, ZrO_2 had no effect. A purely catalytic oxygen liberation, without chem. reaction, was observed with CuO, MgO, CaO, CdO; mixed crystals might be formed. The oxides Ar_2O_3, Sb_2O_3, Cr_2O_3, Fe_2O_3, the various oxides of Mm, Ni, Co(?) were themselves higher oxidized; in the cases of Cu_2O, V_2O_5, Sb_2O_3, Cr_2O_3, MnO_3, MnO, the reaction velocity became enormous, between 200° and 300°. Alumina gave aluminate; lead oxide (litharge) did not liberate oxygen until near 500°, yielding a barium plumbate. (*Sci. Abs.*)

29. Cohesion. H. CHATLEY. *Phil. Mag.*, **40,** 213–17(1921).—C. proposes the empirical cohesion formula for the mean cohesions of hypothetical atom spheres, $f_2 = G_m^2/d^{2+n/k}$, where n is between 4 and 5, f_2 is the cohesion bond, k is the ratio (>1) of mean atomic interval to that at absolute zero, while

G, m, and d are as in the Newtonian formula, for gravitational force. The mud resists erosion until the hydrodynamic tangential drag on a surface particle equals about 10^{-6} dyne; *i. e.*, each particle, containing some millions of molecules, is retained by at least one intermolecular cohesion bond, with the result that fine mud beds are not easily eroded, whereas coarser sand is easily moved. Also colloidal suspension and plasticity in gels becomes of importance when the wt. of particles is about equal to one inter-molecular cohesion bond, *e. g.*, with cubic particles, sp. gr. 2.5, each has a diameter $d = 10^{-6}/2.5^{-1} \times 981)^{1/3} = 9 \times 10^{-4}$ cm. This agrees with the dimension usually assigned as a max. to colloidal particles. (*Sci. Abs.*)

30. Liquefaction of carbon. E. RISHKEVICH. *Z. Electrochem.*, **27,** 445–52 (1921); cf. *C. A.*, **15,** 1432.—Pure C has been melted at ordinary pressure. Under favorable conditions (high current and good isolation) C can be brought into a molten state by using low c. ds. The drops formed on allowing molten C to cool consist of pure graphite. The sublimation point of C at ordinary pressure lies not far from its m. p. In satd. C vapor unusually large and excellent crystals can be formed. H. S. C. (*C. A.*)

31. Kaolin in North Carolina, with a brief note on hydromica. W. S. BAYLEY. *Econ. Geol.*, **15,** 235–46(1920).—The kaolins are found in pegmatite veins in the mountain regions and as blanket deposits derived from broad areas of igneous or metamorphic rocks in the Piedmont plateau. The downward gradation of the kaolin into pure feldspar in the pegmatic veins and retention of the characteristic texture of the pegmatite show that the kaolin occupies the place of the feldspar in the original pegmatite. Of the 3 generally accepted kaolinization processes of feldspar, it is believed that the true one in this case is downward traveling H_2O bearing dissolved CO_2 and org. matter along feldspathic dikes. The alteration of minerals other than feldspar includes soln. of quartz in some cases, possibly by alkalies. Beryl changes to scaly mica and kaolin. Biotite, hornblende, tourmaline, and other ferruginous minerals have altered to chlorite and hydrated micaceous minerals, limonite, and other Fe oxides, and to an Fe carbonate. A good specimen of so-called "hydromica" gives unsatisfactory and generally indefinite optical and chemical data and is believed to represent an aggregate of fine-grained decompn. products embedded in a matrix containing residual muscovite. Owing to water and increasing feldspar content the dikes can not usually be worked for kaolin to a greater depth than 95 feet. Analysis of feldspars, kaolins, and hydromica are given. A. B. PECK (*C. A.*)

32. Studies on the gel of silicic acid. R. SCHWARZ. *Kolloid-Z.*, **28,** 77–81 (1921).—A review of S.'s work (*C. A.*, **11,** 764; **14,** 1083, 1942; **15,** 214) with special reference to the colloidal phases. H. I. MATTILL (*C. A.*)

33. Chemistry of the earth's crust. HENRY S. WASHINGTON. Geophysical Lab. *J. Franklin Inst.*, **190,** 757–815(1920). (*C. A.*)

34. Adsorption of gas by charcoal, silica, and other substances. HENRY BRIGGS. *Proc. Roy. Soc.* (London), **100A,** 88–102(1921).—The method of detg. the adsorptive capacity of a substance at liquid-air temp. is described,

and results are given of the capacity of silica and certain charcoals. They are compared, especially as relates to N and H, to illustrate preferential adsorption and to show the influence of chem. compn. on gas adsorption. The effect of compressibility of the initial layer, when the d. of the adsorbent is detd. by the immersion method, is considered. An evaluation is made of (*a*) vol. of solid matter, (*b*) that of the interstitial space between the granules, and (*c*) that of the internal gaseous space for silica and coconut charcoal. A high capacity silica may be deactivated, and in the inactive state remains porous. The evidence leads to the conclusion that de-activated silica is vitreous. It is argued that a vitreous solid, like a crystal, is a polymer, *i. e.*, a complete at. linkage. The importance of distinguishing between the coarser capillaries or canals and the finer interpolymeral openings of an adsorbent is emphasized. Activation is considered to be the effect of disrupting the solid polymers, and the means of accomplishing the partial depolymerization of charcoal and silica is described. E. P. WIGHTMAN (*C. A.*)

35. Determination of the valence scale of iron, cobalt, nickel, copper, manganese, tin and tungsten by means of water vapor equilibrium, and the dissociation pressure of the oxides of these metals. LOTHAR WÖHLER AND O. BALZ. *Z. Elektrochem.*, **27**, 406–19(1921).—The H_2O-vapor equil. over the phases Fe_2O_3/Fe_3O_4 and Fe_3O_4/FeO has been detd., at several temps., by the reduction of the higher and the oxidation of the lower stage (*i. e.*, from both sides), with a modified form of the app. previously employed by W. and Prager (*C. A.*, **12**, 554). Quant. measurement of the accompanying quantity of H and the detn. of special equil. for each oxide show that the stability of the oxides of Fe follows the order of chem. valence: Fe_2O_3, Fe_3O_4, FeO. It has been found that FeO is formed at red heat from Fe and H_2O, and not a mixt. of Fe and Fe_3O_4. In agreement with Hilpert and Beyer (*C. A.*, **5**, 2785), it has been found that reduction of Fe_2O_3 first begins between 280 and 330°, according to the mode of prepn. of the oxide. The heat of reaction of the processes, $Fe+O=FeO$ and $3FeO+H_2O=Fe_3O_4+H_2$, has been calcd. by means of the van't Hoff equation for the reaction isochore for different temp. intervals. The dissoc. pressure of the different oxides has been calcd. from the equil. consts. and the formation consts. The values obtained are very small, and for the oxides of Sn, of Fe and of W, have values between 10^{-11} and 10^{-12} mm. Hg at 1000°. H. JERMAIN CREIGHTON (*C. A.*)

36. Feldspar in 1920. L. M. BEACH. U. S. Geol. Survey, *Mineral Resources of U. S. Geol., 1920*, Part II, 153–4(preprint No. 18, published Oct. 29, 1921). E. H. (*C. A.*)

37. The estimation of small quantities of lime in presence of large quantities of magnesia. J. S. F. GARD. *Proc. Univ. Durham Phil. Soc.*, **5**, 234–5 (1915).—If the pptn. of CaC_2O_4 takes place in dil. soln. contg. considerable NH_4Cl and dil. AcOH, it is possible to effect satisfactory sepn. of a little Ca from considerable Mg. To a soln. contg. the equiv. of 5 g. MgO in water or dil. HCl, add 5 g. of NH_4Cl and NH_4OH until alk. Filter off the $Fe(OH)_3$, etc., make the filtrate acid with AcOH, using a moderate excess, and dil. to 450 cc.

At the boiling temp., add 50 cc. of a cold satd. soln. of $(NH_4)_2C_2O_4$, continue boiling 5 min. and allow to stand 20 hrs. Decant off the supernatant Mg soln., dissolve the CaC_2O_4 in 6 *N* HCl and repeat the pptn. as before beginning with the neutralization by NH_4OH but allowing this ppt. to stand only 30 min. If the ppt. cakes or sticks to the glass repeat the process once more.

W. T. H. (*C. A.*)

38. Physical chemistry of the oxides of lead. I. Solubility of lead monoxide. S. GLASSTONE. *J. Chem. Soc.*, **119**, 1689–97(1921). (*C. A.*)

39. General colloid chemistry. III. The physico-chemical analysis of zirconium oxychloride and of zirconium oxide sols. MONA ADOLF AND WO. PAULI. *Kolloid-Z.*, **29**, 173–84(1921). (*C. A.*)

40. The colloidal state and colloidal terminology. A. A. POLLITT. *Chem. Age* (London), **5**, 586–8(1921).—A review. E. H. (*C. A.*)

41. Preparation of zirconia. ANON. *Chem. Trade J.*, **68**, 1745(1921).—Equal parts zirkite and caustic soda were fused in an iron crucible, the final temp. being visible redness. The product was treated with water, filtered, and the residue treated with HCl and evapd. to dryness. The insoluble material after ignition amounted to 20% of the zirkite used and contained 61% ZrO_2, 29% SiO_2, 1% Fe_2O_3, and 2% Al_2O_3. The zirconia was precipitated from the soln. as the easily filtered basic sulphate. The ppt. was amber colored, easily soluble in conc. H_2SO_4, slightly in HCl and was completely decomposed by boiling with sodium carbonate of ammonia. The hydroxide precipitated by ammonia was dissolved in HCl, evapd. and allowed to cryst. forming needle-like $ZrOCl_2.8H_2O$. A quantitative separation of zirconia from large amts. of iron was found possible.

PATENTS

42. Contact body with ceramic material as carrier. V. ZIEREN. Ger. 317,979, Oct. 25, 1917. The contact body consists of a thin-walled porous member provided with channels to permit the passage of gas, and in certain circumstances with projections. The walls are covered completely with contact substance. The thickness of the walls does not exceed 2 mm., and the cross-section is not more than 20 mm. (*C. A.*)

43. Soluble compounds from feldspar. H. S. BLACKMORE. U. S. 1,355,381, Oct. 12. Finely divided orthoclase or a similar material is heated under pressure with a soln. of Al silicofluoride for 3–5 hrs. to form K_2SiF_6. Insol. matter is sepd. and the soln. is allowed to cool to effect deposition of K_2SiF_6. The aluminous residue obtained as a by-product may be employed as a china clay for manuf. of crockery. Na_2SiF_6 and $(NH_4)_2SiF_6$ also may be used instead of $(Al)_2(SiF_6)_3$. This method avoids the disadvantage of corrosive action of HF on the app. such as may occur when H_2SiF_6 is used to decompose silicates. U. S. 1,355,588 relates to a similar method in which $FeSiF_6$ is used as the decomposing agent with or without the addition of $(NH_4)_2SiF_6$, in obtaining sol. compds. from orthoclase, leucite, glauconite or similar minerals. The reaction is preferably carried out under 200 lbs. pressure per sq. in. at a temp. of about 175°. (*C. A.*)

44. Increasing the adhesive properties of alkali silicate solutions. W. DAHSE. Ger. 318,516, Aug. 23, 1918. Alkali silicate solns. are treated with solns. of water-sol. Zn or Cd salts. *E. g.*, to Na_2SiO_3 soln. of 36° Bé., are added gradually, with continued stirring 0.6–1% of $ZnCl_2$ which has been previously dissolved in 10 times its weight of H_2O. At first a gelatinous mass seps. which during the progress of the reaction is converted into a viscous, strongly adhesive mass. (*C. A.*)

45. Aluminium oxide. H. J. GOLDSCHMIDT. U. S. 1,354,824, Oct. 5. Plagioclases of the labradorite-anorthosite series or other materials containing Al and other metals such as Ca, K and Na are treated with HNO_3 and the nitrates formed are subjected to a temp. of about 300° in order to convert the $Al(NO_3)_3$ into oxide without affecting the other nitrates. Cf. *C. A.*, **14,** 1598. (*C. A.*)

46. Magnesium carbonate. B. B. GRUNWALD. U. S. 1,361,324, Dec. 7. Calcined magnesite is hydrated with H_2O and the liquid mass thus obtained is subjected to the action of CO_2 under pressure to produce $MgCO_3$ and $Mg(HCO_3)_2$ in the form of a milky mixt. Calcined magnesite is added to the mixt. as it comes from the digester with an excess of CO_2 in soln. and the mixt. is agitated and heated to ppt. basic Mg carbonate. (*C. A.*)

47. Apparatus for producing magnesium carbonate from calcined magnesite. B. B. GRUNWALD. U. S. 1,361,325, Dec. 7. The app. comprizes a hydrating chamber to which a supply of CO_2 is connected, a heated pptg. device and other devices adapted for carrying out the method described in U. S. 1,361,324 (preceding pat). (*C. A.*)

Refractories and Furnaces

48. The magnesite plant of Austro-American Magnesite Company at Radenthein (Kärnten). K. ENDELL. *Met u. Erz.*, **18,** 597–600(1921).—The plant manuf. dead-burned magnesite and magnesite brick. The raw mag. is calcined (1700°C) in revolving fur. The mag. brick are pressed under 1000 kg. per sq. cm. and fired in a tunnel kiln to 1500°. Total employees number 910. The prod. of d.b. mag. is about 1,115,000 tons and that of mag. brick about 21,000 T. per annum. A Cottrell precip. app. is in process of installation in the revolving fur. ED.

49. On the application of generator gas-firing in the ceramic industry. K. TEICHMANN. *Ber. D. K. Ges.*, **1** (3), 32(1920).—The writer claims that with the recuperative system kiln temperatures up to cone 16 can be obtained, using a gas manufactured from low grade brown coals. The writer also claims that the value of the tar produced in one year would pay for the initial cost of installation.

50. What happens during firing. R. SEYDEL. *Tonind. Ztg.*, **44,** 951(1920).

51. Thermal "balance-sheet" of an annular kiln. R. CLAUS. *Tonind. Ztg.*, **44,** 1009(1920).

52. Firing with artificial draught. H. SA. *Tonind. Ztg.* **44,** 1045(1920).—Description of grates with injectors and air pipes, nozzle app., adjustable steam distributors, etc.

53. The "Herda" kiln. ANON. *Sprech.*, **53,** 535(1920).—The hot air from the cooling chambers is mixed with the gases of combustion from the chambers under fire, thus insuring complete combustion of all carbonaceous matter before the hot gases reach the ware to be preheated.

54. Practical economies in firing pottery. E. REUTLINGER. *Ber. D. K. Ges.*, **1**(3), 20(1920).—A general discussion for the purpose of promoting coöperation between the German Ceramic Society and the Society of Heat Engineers.

55. Heat saving investigation on kilns. E. REUTLINGER. *Ber. D. K. Ges.*, **2,** 33(1920).—Field tests were made on 16 annular kilns in diff. ceramic plants. The preliminary results indicate that: (1) the firing period is too long; (2) fuel consumption is too high; (3) firing is irregular; (4) per cent of rejection is too high. In almost all cases the defects can be removed by comparatively simple means. In one case the firing period was reduced from 32 to 24 hours and the chem. constn. of the flame kept under control during both the oxidation and reducing periods. The work is being continued under the auspices of the German Ceramic Society for the purpose of discovering defects and making improvements and of training the workmen, the introduction of systems of control and permanent inspection and supervision of firing.

56. Theory of the carbon gasification process. WO. OSWALD. *Chemiker Zeit.*, **43,** 229–31(1919).—When carbon is gasified on the grate or by the aid of steam in a producer, 8 reactions may take place which may be summed up in 3 equations. (1) $C + O_2 = CO_2 + 97.6$ cals.; (2) $C + 2H_2O = CO_2 + 2H - 18.8$; (3) $C + CO_2 = 2CO - 38.8$. When these reactions take place in the proportions a, b, c, the complete process is: $(a+b+c)\,C + aO_2 + 2bH_2O = (a+b-c)\,CO_2 + 2bH_2 + 2cCO + 97.6a - 18.8b - 38.8c$. The presence of CH_4 and of N is disregarded. Only 2 of the 3 quantities a, b, c, are independent variables. They are detd. by analyses and the results are plotted by the triangular coördinates of Gibbs. The triangle is divided into regions of combustion and gasification, and of regeneration. The author shows how isothermals and isocalorics are diagrammatically represented, and how the chemist may det. the thermochemical and volumetric characteristics of combustion under varying working conditions, the amt. of coal consumed, the heating value of the gas produced, etc. (*Sci. Abs.*)

57. Refractory crucibles. ANON. *Metal. Ind.*, **17,** 369(1920).—Crucibles can be manufd. by tapping plastic mixts. of highly refractory oxides into fire-clay mould lines with plaster of Paris and then firing the crucible and the mould to a red heat. The crucible can then be removed and given a further firing at high temp. Another method is to use linseed oil as a temporary binder, the crucible being shaped in a metal mould. Crucibles have been made in this way from TiO_2ZrO_2 and CaC.

58. The separation of mineral matter from natural flake graphite. W. C. RATLIFF AND J. D. DAVIS. *Chem. Met. Eng.*, **23,** 1027–8(1920).—Expts. show that while graphite flake or amorphous, may be cleaned by agitation with oil and water, light volatile liquids such as C_6H_6, C_7H_8 and CCl_4 are even better. The agglomerates formed with the volatile liquids are less viscous and the mineral matter is sepd. with less agitation than in cases where heavy oil has been used. Fineness has a direct bearing upon the effectiveness of the cleaning. W. H. BOYNTON (*C. A.*)

59. Stability of conducting (electric) furnace hearth structures. F. HODSON. *Elec. Rev.* (Chicago), **79,** 911–2(1921).—The conductive hearth of the Greaves-Etchells furnace has given exceptionally good service. One of the furnaces installed in June, 1907, has worked continuously with the production of thousands of casts and is still in operation on the original hearth. In one of the large works the practice is followed of chipping out about 4 or 5 in. of the top surface of the hearths once a month and re-ramming new material in. This is done more as a metallurgical precaution to insure clean steel, but the real linings of these furnaces have not been changed for years. There is no doubt that a hearth of this type, when intelligently installed and maintained is practically permanent. In the Greaves-Etchells furnace, 2 phases of the 3-phase current are taken through top electrodes and the third phase is connected directly to a Cu plate lying underneath the lining. No studs project into the lining, and after putting a few inches of special C compd. over the Cu plate, the whole lining of standard *dolomite* or *magnesite* is rammed in with sufficient tar to bind. Details are given. C. G. F. (*C. A.*)

60. Silica brick for coke ovens. A. H. MIDDLETON. *Colliery Guardian*, **122,** 1203–4(1921).—Silica brick is not used extensively in Great Britain for lining coke ovens as it is in U. S. This is a discussion of the present developments in the use of this material for ovens. Also in *Gas World*, **75,** No. 1946 (Coking and By-products Sec.), 13–17(1921); *Gas J.*, **156,** 630–1(1921). C. A. DAVIS (*C. A.*)

61. Firing with brown coal. ANON. *Tonind. Ztg.*, **44,** 1148(1920).—Two illustrations are given of a method of firing boilers with step grates.

62. The reconstruction of grates for firing with lignite and briquettes. O. SCHÖNE. *Tonind. Ztg.*, **44,** 1185(1920).

63. Refractories in the steel plant. A. A. HULL. *Iron Age*, **25,** 1377–8 (1921).—A plea for adequate specifications and coöperation between producer and consumer. E. H. (*C. A.*)

64. War experience with refractory bricks in the German navy. SCHULZ. *Tonind. Ztg.*, **44,** 1047(1920).—Specifs. include the following softening points: cone 34 for grade 1, cone 31 for grade 2, cone 26 for grade 3.

65. The refractory products industry. J. BIED. *Cer.*, **22,** 33(1919); See TRANS., **19,** 134(1920).

66. Refractories for electric furnaces. *Iron and Coal Trades Rev.*, **101,** 616(1920).—A symposium held by the Electric Furnace Association, Columbus, Ohio.

67. Firing temperatures attainable with wood. H. SACHSE. *Tonind. Ztg.*, **44,** 709(1920).—The actual temp. reached in practice with dry wood is approx. 1450°C, with air dried wood containing 20% water, approx. 1000°C and with green wood, approx. 700°C.

68. Firing with coal dust—a solution of the fuel problem. C. DEGELOW. *Tonind. Ztg.*, **44,** 752, 767(1920).—A rept. on Amer. experience with powdered coal as a fuel.

69. Coal saving. W. ENGLEHARDT. *Tonina. Ztg.*, **44,** 877(1920).—A few general remarks chiefly concerning the regulation of draught.

70. Heat saving in revolving kilns. E. SCHOTT. *Tonind. Ztg.*, **44,** 781 (1920).—The author recommends a combined rotary-grate, revolving, tubular kiln.

71. Design of open hearth furnaces. A. D. WILLIAMS. *Iron Age*, **105,** 35, 119(1920).—A thorough discussion of the whole subject.

72. A war-time lime kiln. W. HÄNSE. *Tonina. Ztg.*, **44,** 717(1920).

PATENTS

73. Electric insulating compositions. BLERIOT, LTD. Brit. 147,746, July 8, 1920. A compn. for elec. insulation, especially designed for use with elec. heating and cooking app., consists of carborundum with a soln. of K_2SiO_3 or Na_2SiO_3 as a binding medium, with or without the addition of washed sand and powdered quartz or glass. The mixt. is baked at a temp. of 400–500°. (*C. A.*)

74. Furnaces. H. J. F. PHILIPON. Brit. 164,746, May 30, 1921. Thin tubes of fused quartz are employed in the construction of regenerators. (*C. A.*)

75. Making films of silica, alumina, etc. M. DE ROÏBOUL. Brit. 169,136, Nov. 19, 1920. Relates to drawing films of SiO_2, Al_2O_3, or like refractory substance having a thickness of the order of 0.001 mm. and a width of about 6 cm. Such films are strong and flexible. The app. employed is generally similar to that described in 165,052 for the drawing of filaments. Pairs of parallel wires of Ir, etc., passed over pulleys and wound on a drum draw up a film from a bath of the molten material. The drawing may be started by a cross wire. The wires may be cut away from a film when it is subsequently unwound from the drum, or they may be severed from it as it is wound on to the drum. (*C. A.*)

76. Refractory material. O. HUTCHINS. U. S. 1,362,316, Dec. 14. A refractory material suitable for furnace linings, crucibles or muffles is formed of a burnt mixt. of zirconia and alumina. (*C. A.*)

77. Basic refractory composition. H. P. BASSETT. U. S. 1,360,355, Nov. 30. A basic refractory compn. suitable for lining open-hearth furnaces or Bessemer converters is formed of magnesium limestone 100, Fe scale or oxide 1–2, NaCl 2 and SiO_2 2–10 parts, heated to a high temp. and prepd. in granular form. (*C. A.*)

78. Improvement of furnace using gaseous fuels. A. C. IONIDES, JR. Japan 35,862, Feb. 21, 1920. (*C. A.*)

79. Furnace lining. J. F. MOLLEN and W. W. PATNOE. U. S. 1,356,336, Jan. 11. A material adapted for lining furnaces is prepd. by making a slurry of raw dolomite, adding a small per cent of NaCl and then passing the mixt. through a rotary kiln operated at a temp. sufficiently high to calcine the dolomite and volatilize the NaCl. The presence of the NaCl serves to maintain the material in granular form. (*C. A.*)

80. Temperature-control devices for electric furnaces. E. F. COLLINS. U. S. 1,391,996, Sept. 27. Automatic devices are specified for successively maintaining different predetd. temps. in elec. furnaces such as those used for heat-treating steel or other metals. (*C. A.*)

81. Insulating and heat-conducting material for electric heaters. R. W. EARLE. U. S. 1,358,366, Nov. 9. An elec. insulating and heat-conducting material for elec. heaters is formed of a granular material of high dielectric strength and thermal concd. such as fused Al_2O_3 85% mixed with refractory clay 15% or similar bonding material of high dielectric strength and high fusing point and capable of forming a viscous mixt. with H_2O. (*C. A.*)

82. Refractory and protective coating on furnace linings. E. R. STOWELL. U. S. 1,350,343, 1920. Mix 8 lbs. powdered SiC with 1 gal. of a 4% soln. of NaOH with water, stir and add 1 pt. of a 50% Be soln. of sodium silicate.

See Abs. 41.

Abrasives

83. The crystalline characters of calcium carbide. C. H. WARREN. Mass. Inst. Technology. *Am. J. Sci.*, **2**, 120–128(1921).—CaC_2 from the elec. fur. is a granular or columnar-cryst. aggregate, geometrically pseudo-cubic, but intricately twinned. True symmetry probably orthorhombic, or perhaps tetragonal. Cleavage perfect in three mutually perpendicular directions. Twinning highly polysynthetic; grains are made up of groups of lamellae, parallel to cleavage or at 45°. Color by transmitted light purplish red or lilac-yellow. Transparent only if less than 0.02 mm. thick. Indices of refraction above 1.75; double refraction above 0.050. (For further details on interference figures, etc., see original.) The reaction with water to form C_2H_2, when it is made to take place slowly, leaves the microscopic structure undisturbed. *Calcium cyanamide* is usually also present. Properties: rhombohedral symmetry and cleavage; colorless; refractive indices: $\omega = 1.60$, ϵ, very large; double refraction unusually large, over 0.35; optically positive.

R. B. SOSMAN

84. Abrasive materials in 1920. L. M. BEACH AND A. T. COONS. U. S. Geol. Survey, *Mineral Resources of U. S., 1920*, Part II, 155–9(preprint No. 19, published Oct. 28, 1921). E. H. (*C. A.*)

Stoneware, Whiteware and Porcelain

85. Kaolins and pottery clays in the U. S. A. V. BLEININGER *Brick Clay Record*, **60**, 39–42(1922).—Eng. china clay in 1 : 1 clay-flint mixts. has a dry transverse strength of 35 lbs. per sq. in. and an absorption of 24% when fired

at cone 8. In similar mixts. N. Car. kaolin has a transverse strength of 25.5 lbs. per sq. in. and an absorption of 25.5% when fired at cone 8. The primary clays in this country are not always of high quality because of improper refining methods. Fla. kaolin develops a stronger body than Ga. kaolin. For example in 1 : 1 clay flint mixts. Fla. kaolin has a transverse strength of 250 lbs. per sq. in. while Ga. kaolin has a dry strength of 25 lbs. per sq. in. Ga. clays develop considerable cracks and checks in drying. Ball clays may be divided into five classes as follows: (1) Black and dark ball clays containing considerable organic matter, inclined to be sticky and vitrify below cone 8. In 1 : 1 clay flint mixts. the transverse strength is about 475 lbs. per sq. in. (2) Dark ball clays having the same physical properties as class 1 except that they vitrify above cone 8 but not above cone 10. (3) Blue, gray or yellowish clays, much lower in org. matter than the black clay. The dry strength of the 1 : 1 clay flint mixts. have a transverse strength of 350–400 lbs. per sq. in. and vitrify below cone 8. (4) Clays similar to class 3 except that they vitrify above cone 8 but not cone 10. (5) Clays similar to class 3 and 4 but having a transverse strength of 240–350 lbs. per sq. in. and vitrify between cones 11–12. It is desirable for the ball clay to vitrify during the bisque fire since more refractory clays tend to produce more open and less strong bodies which are apt to craze. No clay which fires to a gray should be used. In cream colored clays, however, this tinge may be neutralized with cobalt. The requirements of a good feldspar are as follows: (1) The spar should have a silica content of not over 69%. (2) The potash should not be below 9%. (3) The soda content should not be above 3%. (4) The spar fired at cone 8 should be thoroughly fused but not flatten out or change its shape markedly. (5) The color of the fired spar should show a white and not a gray-black color and should not show an excessive no. of specks. The sagger clays may be classified as follows: (1) Those having a drying shrinkage of 7% and a fire shrink. at cone 8 of 5.5%; absorption at cone 8 2.5%, transverse strength in the dry state of 120 lbs. per sq. in. They have good strength in the first fire but overburn gradually and sometimes soften in subsequent firings. (2) Drying shrink. 6.2%, fire shrink. 3.4%, absorption at cone 8 is 12%, dry strength is 120 lbs. per sq. in. Does not overfire but continues to shrink on firing. (3) Drying shrink. 7%, fire shrink. 6.8%, absorption 2.3%, dry strength 220 lbs. per sq. in. Does not shrink or overfire in repeated firings. (4) Dry shrinkage 4%, fire shrink. 4%, absorption at cone 8 is 15%, strength is 80 lbs. per sq. in.; is quite high in silica and does not overfire. Clays 1, 2 and 3 give best results. H. G. SCHURECHT

86. Stoneware cooking utensils. E. TUSCHOFF. *Tonind. Ztg.*, **44,** 729 (1920).—Description of the process of manuf.

87. Stoneware pipes. ANON. *Tonind. Ztg.*, **44,** 666(1920).—The thinner pipes made in Germany for export have more even and dense bodies than the thick walled ones made for the home market.

88. Clay or stoneware utensils for poultry farms. A. WULF. *Sprech.* **53,** 442(1920).

89. The packing of Gay-Lussac towers. GEORGE SCHLIEBS. *Chem.-Ztg.*, **45,** 1038–9(1921).—Manufd. *stoneware* packing is superior to coke on every count. Such a packing must, however, be as light as possible without crushing under its own wt., must be entirely acid-proof and should possess rough walls. A patented packing consisting of a small cylinder made integral with and inside a larger cylinder is described. F. C. Z. (*C. A.*)

90. Hard stoneware body for electric insulators. ANON. *Sprech.*, **53,** 533(1920).—The following body fires satisfactorily at cone 6–8:

$$\left.\begin{matrix}0.56\ KNaO \\ 0.44\ Ca(Mg)O\end{matrix}\right\} : 1.6\ Al_2O_3 : 9.2\ SiO_2$$

91. High tension insulator porcelain. W. D. A. PEASLEE. *J. Amer. Inst. E. E.*, **39,** 445(1920).—The subject is discussed under the following headings: (1) mechanical strength, (2) ability to resist sudden changes in temp., (3) porosity, (4) temp. resistivity coeff., (5) Piezo elec. effect, (6) surface leakage as a factor in insulator design.

92. Firing stoneware pipes. W. SCHUEN. *Tonind. Ztg.*, **44,** 1001, 1035 (1920).—A method of arriving at a thermal balance sheet.

See Abs. 14, 119.

Glass

93. Double refraction of glass under pressure. E. AND MME. HENRIOT. *Comptes Rendus*, **172,** 1477–79(1921).—The dispersion produced in crown glass is not independent of wave-length, but it obeys very closely Havelock's law that the expression $n(n'-n''/')/(n^2-1)^2$ is constant where $n'-n''$ is the dispersion produced at wave-length n. (*Sci. Abs.*)

94. Copper ruby glass for casing. J. BALDERMANN. *Sprech.*, **53,** 491 (1920).—A discussion of batch compn. and methods of melting.

95. Copper ruby glass for casing. E. S. *Sprech.*, **53,** 536(1920).—A reply to Baldermann—see above.

96. Circular flattening ovens and lehrs for plate glass, bottles, etc. C. BALDERMANN. *Sprech.*, **53,** 444(1920).—A description with sketch.

97. The manufacture of optical glass. C. J. PEDDLE. *Trans. Opt. Soc.* **23,** 2 (1921–22).—The history of the manuf. of opt. glass is discussed under the headings, (1) *early attempts*, (2) 1790–1886, (3) 1886–1914, (4) 1914 onward. Except for the bibliography the discussion of the 4th period is confined to developments in England. A good outline descrip. of the meth. of manuf. is given. Nine excellent photomicrographs of various types of stones are reproduced. The reln. between properties and compn. are displayed in the following diagrams:

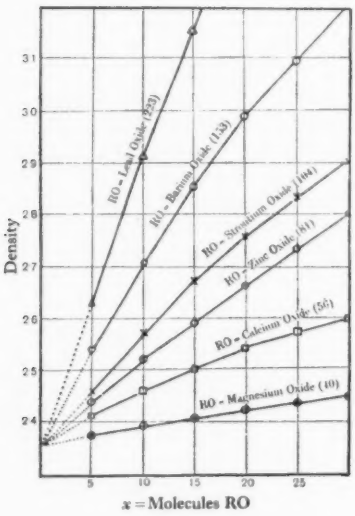

Density
RO = Lead Oxide (329)
RO = Barium Oxide (153)
RO = Strontium Oxide (104)
RO = Zinc Oxide (81)
RO = Calcium Oxide (56)
RO = Magnesium Oxide (40)
x = Molecules RO

FIG. 1.

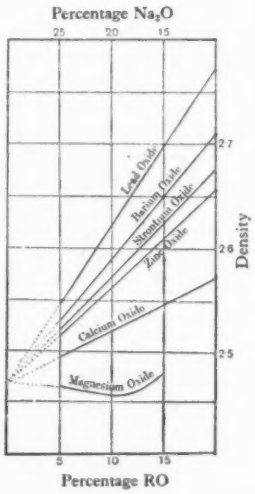


FIG. 2.

FIG. 1.—Relationship between molecular composition and density in the series 100 mols. SiO_2 . 20 Na_2O . xRO.

FIG. 2.—Percentage composition and density (silica constant = 70 per cent).

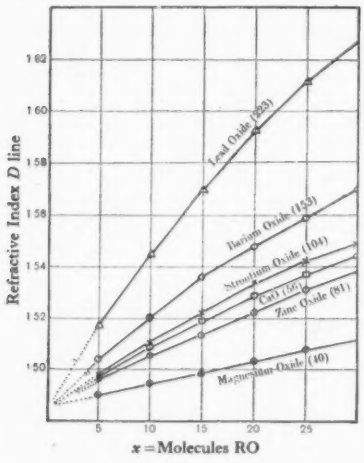


FIG. 3.

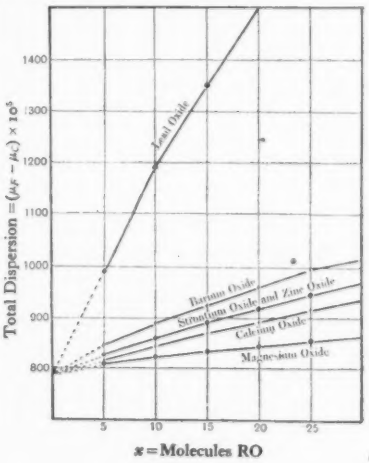


FIG. 4.

FIG. 3.—Relationship between molecular composition and refractive index (μ_D) in the series 100 mols. SiO_2 . 20 Na_2O . xRO.

FIG. 4.—Relationship between molecular composition and total dispersion in the series 100 mols. SiO_2 . 20 Na_2O . xRO.

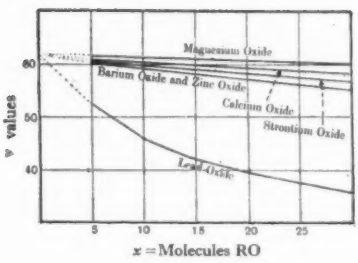


FIG. 5.

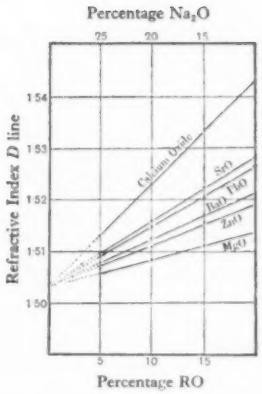


FIG. 6.

FIG. 5.—Relationship between molecular composition and ν value in the series 100 mols. SiO_2 . 20 Na_2O . xRO.

FIG. 6.—Relationship between percentage composition and refractive index. (Silica constant = 70 per cent.)

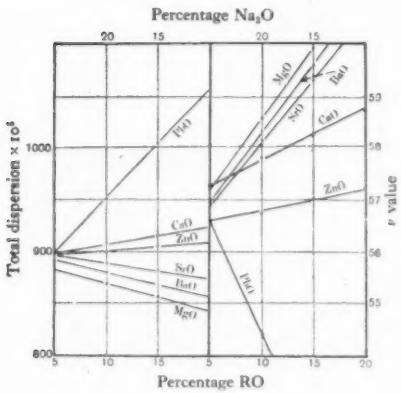


FIG. 7.

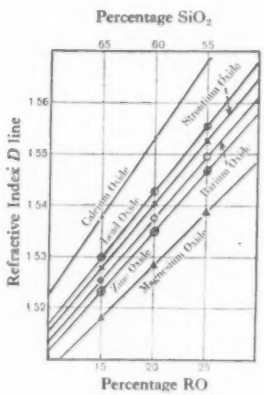


FIG. 8.

FIG. 9.

FIG. 7.—Relationship between percentage composition and total dispersion. (Silica constant = 70 per cent.)

FIG. 8.—Relationship between percentage composition and ν value. (Silica constant = 70 per cent.)

FIG. 9.—Percentage composition and refractive index. (Sodium oxide constant = 20 per cent.)

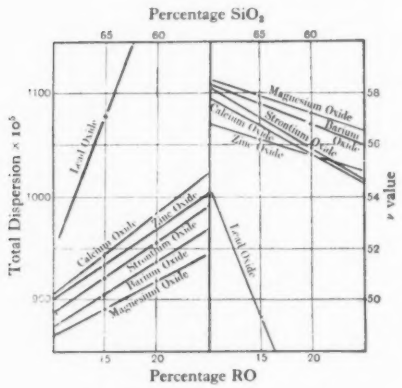


FIG. 10. FIG. 11.

FIG. 10.—Percentage composition and total dispersion.
(Sodium oxide constant = 20 per cent.)

FIG. 11.—Percentage composition and ν value.
(Sodium oxide constant = 20 per cent.)

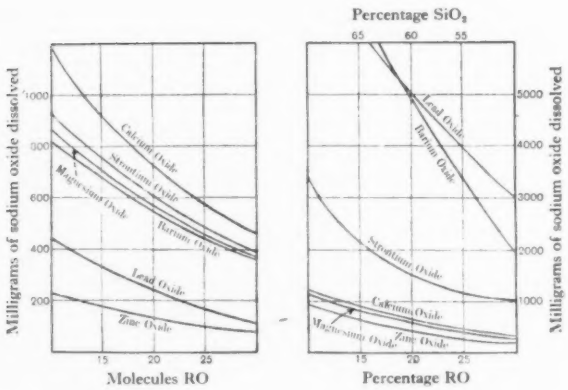


FIG. 12. FIG. 13.

FIG. 12.—Molecular composition and solubility of glasses.
100 SiO_2 . 20 Na_2O . xRO.

FIG. 13.—Percentage composition and solubility.
(Sodium oxide constant = 20 per cent.)

98. Strains in unannealed glass. J. SALPETER. *Zeits. techn. Physik.*, I, **10,** 221–24(1920).—This paper gives further theoretical treatment of the case of a quickly cooled sphere of glass dealt with in a previous paper. (*Sci. Abs.*, **1359,** 1920). (*Sci. Abs.*)

99. High-frequency losses in glasses and other dielectrics. E. SCHOTT. *Jahrb. d. Tele.*, **18,** 82–122(1921). (Extract from Dissertation, Jena.)—For detg. the "angles of loss" of dielectrics in high-frequency fields a method was employed in which a direct comparison was made of the condenser (made up with the dielectric to be investigated) with an air condenser free from losses, and previously calibrated resistance. The angles of loss (in minutes of arc) found for the different substances dealt with are given as follows: glass, 1.5 to 90; quartz, 0.4; good mica, 0.6; pressed amber, 18; presspan, about 100. *Temperature effect.*—The increase of the angle of loss with temp. for glasses is very marked. At the highest temp. employed (about 400°C) the loss can be assigned to pure conductivity. At ordinary room temp. the loss calcd. from the d.c. resistance was generally much less than 1% of the observed h.-f. loss. (*Sci. Abs.*)

PATENTS

100. Method of operating optical pyrometers. E. A. KEELER. U. S. 1,379,188, May 24. (*C. A.*)

101. Apparatus for analyzing flue gases. HERBERT M. SHARP. Can. 211,201, May 3, 1921. The app. consists of an elec. circuit, a receptacle contg. conducting liquid, in which electrodes are submerged, a conduit delivering gas into the liquid and past one of the electrodes so that the gas bubbles emerging from the conduit press the conducting liquid away from the electrode and interrupt the circuit and means controlled by the circuit for indicating the number of interruptions. A desired number of such receptacles is connected in series, each contg. an absorbent for a particular constituent of the gas. (*C. A.*)

102. Putting the glass industry on a scientific basis. E. WARD TILLOTSON. *Chem. Met. Eng.*, **23,** 461–5(1920).—A general discussion of the problems of the glass industry with the improvements which have been made, particularly by substitution of continuous and machine processes for intermittent and hand processes. Contributions of American inventors are noted and a plea is made for the scientific coöperation between the practical glass maker and the technologist necessary for adequate plant control and research.

J. S. LAIRD (*C. A.*)

103. Annealing of glass. L. H. ADAMS AND E. D. WILLIAMSON. Geophys. Lab. *J. Franklin Inst.*, **190,** 597–631, 835–70(1920).—In order to anneal glass properly the rate of release of the internal stresses must be known for the various glasses and the various temps. A record is given of such measurements for 9 kinds of glass; and mathematical formulas are derived for calcn. of the release of stress, and for calcn. of the stresses due to heating or cooling various shapes of glass. At any temp., a glass requires a certain annealing time which is arbitrarily defined as the time required to reduce the

stress, in optical units, from 50 to 2.5 micromicrons per cm. The annealing range is the interval of 150° lying immediately below the temp. at which the annealing time is 2 min. Very little permanent stress can be introduced at temps. below the annealing range. Concrete directions are given for annealing various kinds of glass; the best procedure is to hold the glass at a const. temp. at the annealing point for the proper time, then to cool at an increasing rate. JOSEPH S. HEPBURN (*C. A.*)

104. Glass blowing. Internal welding. H. VIGREUX. *Chimie & industrie*, **4**, 334–6(1920).—The difficulties of internal glass welding are discussed and directions for this operation are given. Cf. *Jour. Am. Ceram. Soc.*, **3**, 932. E. H. (*C. A.*)

105. Composition of acid paste. ANON. *Schnurpfeil's Rev. Glass Works* **4**, 669(1920).—This acid paste is recommended for fine designs: Powdered K_2SO_4 11, KF 20, HCl 11, HF 3, flour 22. ROBERT J. MONTGOMERY (*C. A.*)

106. Silica-glass prism for refractometry of liquids at elevated temperatures. F. R. v. BICHOWSKY AND H. E. MERWIN. *J. Optical Soc. Am.*, **5**, 441–3(1921).—A method is given for the construction of a small hollow fused-silica prism for the refractometry of liquids at elevated temps. An elec. heated furnace to be mounted on a goniometer for use with such prisms also is described. Values are given for the *refractive index* and *dispersion of glacial acetic acid*, *α-chloronaphthalene*, and const. boiling *sulfuric acid* from room temps. to near the b. p. F. R. B. (*C. A.*)

107. The manufacture of glass with indigenous alkali. J. P. SRIVASTAVA. *J. Indian Inaustries and Labor*, **1**, 333–40(1921).—Alkali manufd. from a natural Na_2CO_3 occurring during the dry season in India as a surface efflorescence can be used in the manuf. of colored glass, thus reducing the cost by 30%. The incrustations in which Na_2CO_3 predominates are known as "*reh*" or "*sajji-matti*." The following per cent compn. represents an av. of more than 500 tests: Insol. matter 3.3–8.4, Na_2CO_3 48.2–60.2, NaCl 0.2–4.3, Na_2SO_4 0.3–7.2, H_2O 30.3–38.2, together with a small quantity of org. matter. A careful selection of the deposits is necessary to keep the NaCl content at a minimum. This indigenous soda can be purified on a com. scale to yield a product contg. 90–95% Na_2CO_3 which competes successfully with imported soda ash as a raw material for the production of colored glass.
J. B. PATCH (*C. A.*)

108. Optical glass. F. WEIDERT. *Umschau*, **25**, 534–40(1921); 4 figs.—A brief description in non-technical language of the history and operation of the optical glass firm of C. P. Goerz A.-G. of Munich. J. B. PATCH (*C. A.*)

109. Cornu's method of determining the elastic constants of glass. H. T. JESSOP. *Phil. Mag.*, **42**, 551–68(1921).—Certain errors in Cornu's exptl. arrangement are pointed out, and new measurements are reported for a number of different glasses using an improved method. The change of Young's modulus with time is definitely established. S. C. LIND (*C. A.*)

Heavy Clay Products

110. Standard and tentative methods of sampling and testing highway materials. T. R. Agg and A. T. Goldbeck. Bur. Public Roads. U. S. Dept. Agr., *Bull.* **949,** 1–98(1921).—A full text description is given of the methods which the Committee of the Am. Assoc. of State Highway Officials have recommended as official and which have been approved by the Bur. of Public Roads. W. H. Ross (*C. A.*)

111. Manufacturing cost of bricks. Anon. *Tonind. Ztg.*, **44,** 653(1920).

112. The crushing strength of whole and perforated bricks. Hielscher. *Tonind Ztg.*, **44,** 878(1920).—The author gives figs. showing that the perforated bricks are 20% stronger than the whole bricks, owing to their denser condition and more thorough firing.

113. A chainless carrier. Anon. *Tonind. Ztg.*, **44,** 886(1920).—The app. described handles 200 bricks per min.

114. Brick conveyors. Kr. *Tonind. Ztg.*, **44,** 991(1920).—A description of a method of transporting bricks by rail or canal from works to building site. 4 illus.

115. Bog iron ore. Anon. *Deut. Zieg. Ztg.*, **50,** 325(1919).—The ore may be used for making slate-like appearing glazes such as are used on roofing tiles. Analyses are given. A satisfactory mat glaze can be obtained between cones 3*a* and 10. These glazes might be used for face bricks and terra cotta.

116. Improved methods of brick manufacture. A. Bührer. *Tonind. Ztg.*, **44,** 704(1920).

117. Clays for tiles. Anon. *Tonind. Ztg.*, **44,** 1177(1920).—The main requirements are absence of useless impurities, clearness of the fired color and vitrescibility. The vitrification point should not be near a softening point. A satisfactory clay sintered at cone 1*a* to 6 is free from lime, gypsum and pyrites, and is moderately refractory. Thoroughly vitrified ware requires a uniform body.

PATENT

118. Alumina from clay. V. M. Goldschmidt and O. Ravner. U. S. 1,357,089 Oct. 26. Clay or kaolin is calcined at a red heat, lixiviated with HNO_3 to form an Al nitrate soln. and the latter is converted into alumina by calcining or pptn. with NH_4OH. (*C. A.*)

See Abs. 55.

Enamels

119. Anti-corrosive chemical engineering plant. Pumps for corrosive liquids. Anon. Eng. Dept., Guthrie & Co., Accrington, Eng. *Canad. Chem. Met.*, **5,** 341–44(1921); *Engineering*, **110,** 253–54(1920).—Describes centrifugal pumps and other equipment lined with a new ceramic, acid- and heat-resisting coating, called ceratherm, which resembles porcelain. The ceram. lining is cast in the desired form and cemented into place with an acid-proof cement. It is a good heat conductor, resists sudden temp. changes, has high tensile strength and is claimed to be superior to all other ceram. coatings hitherto employed. Ed.

120. Enameling. DE DIETRICH ET CIE. Brit. 165,785, June 22, 1921. A current of purified gas is caused to ignite on entering the enameling chamber, and ignition continues in direct contact with the articles to be enameled. In the gas generator one portion of the gas is drawn off and traverses a condenser, which retains the gas tar, oils, and any liquid or solid distn. product, and another portion is obtained by the gasification of undercarbonized coke and washed after deposition in 2 chambers of a very fine cinder. The 2 portions of gas are then reunited in a disintegrator, which also removes the last traces of oil by means of gas tar. The gases pass through a series of safety strainers and, shortly before entering the enameling chambers, combustion commences owing to the introduction of a current of warm air. Combustion is then started and is completed in the enameling chambers. (*C. A.*)

See Abs. 14.

Cement, Lime and Plaster

121. The slaking of lime when mixed with sand. W. DRAKEBUSCH. *Tonind. Ztg.*, **44,** 1252(1920).—In the manuf. of sand lime bricks, the amt. of sand to be added in the slaking drum process depends upon the amt. of heat generated by the lime during slaking.

122. Light plaster bricks. GROSSHEIM. *Tonind. Ztg.*, **44,** 1259(1920).—Good hard-coal ash free from dust and coarse pieces is mixed with water and plaster and poured into moulds.

123. The Neuss sand lime brick works. B. KREIGER. *Tonind. Ztg.*, **44,** 862(1920).

124. Carbide lime as a building material. ANON. *Tonind Ztg.*, **44,** 1186 (1920).—By-product lime from the acetylene industry is not satisfactory for building purposes.

125. Utilization of old plaster moulds. E. KIRCHHEIM. *Tonind. Ztg.*, **44,** 1206(1920).—The author suggests their utilization as a substitute for infusorial earth as a packing mat.

126. Burning lime with coal with high sulphur content. ED. DONATH. *Tonind. Ztg.*, **44,** 1260(1920).—The quick lime is contaminated with calcium sulphate.

127. Impermeable cement pipes. ANON. *Tonind. Ztg.*, **44,** 878 (1920).

128. Steam meters for sand-lime brick works. ANON. *Tonind. Ztg.*, **44,** 641(1920).

129. Lime and the sand-lime brick industry. B. KRIEGER. *Tonind. Ztg.*, **44,** 774(1920).—Production statistics for Germany.

130. Works management in a cement factory. O. SCHOTT. *Tonind. Ztg.*, **44,** 438(1920).

131. The hot method of preparing sand-lime brick bodies. H. JOLIG. *Tonind. Ztg.*, **44,** 953(1920).

132. Trass and Portland cement. G. FREDL. *Tonind. Ztg.*, **44,** 1123(1920).

133. The influence of mortar on wall strength. SASSE. *Tonind. Ztg.*, **44,** 969(1920).—Results of measurements with diff. mortars.

134. On the porosity strength and absorbing power of certain calcium sul-

phate cements. ALICE B. TAYLOR AND EDITH IRVINE. *Trans. Cer. Soc.*, **20,** 83–92(1921).—Porosity and absorbing power decrease and strength increases with wt. of plaster relative to water. Retarders such as borax allow the use of high percentages of plaster in the mixts. and the securing of great strength thereby. The rate of absorption of water by the plasters was found to depend more on the grading of the holes than on the actual porosity. The use of 1% borax in certain plasters gave lower porosity but a higher rate of absorption. H. F. S.

135. Quick hardening cement developed by the French. E. C. ECKEL. *Eng. News-Record*, **87,** 566–7(1921).—E. discusses a cement which consists essentially of only lime and alumina, the small amt. of silica present being due to impurities in the raw materials and fuel. A typical analysis is lime 50%, alumina 40%, silica, etc., 10%. The cement is made in a small blast furnace charged with coke, limestone and bauxite; and the temp. is sufficiently high to result in fusion, not merely clinkering. One of its advantages is that it hardens rapidly. Test specimens 24 hrs. old show strengths comparable with 28-day Portland cement specimens. Considering the compn. of this fused cement its most remarkable quality, perhaps, is its resistance to sea water and similar solns., for until cement was introduced it was generally considered that the disintegration of Portland cement in sea water was due to its alumina content. Cements low in alumina were favored for marine construction. A railroad used fused cement on a portion of its line along the Mediterranean where normal cements are badly affected by exposure, but this material shows no effects of exposure to sea water. In lab. tests, cubes made with fused cement have been kept in 3 solns. [(1) sea water, (2) satd. $CaSO_4$ soln., and (3) 1.2% $MgSO_4$ soln.] for 9 years and are still intact. Neat briquets made of fused cement to which gypsum was added in all proportions up to 50% have been kept in water since 1908 without the least signs of disintegration. J. C. WITT (*C. A.*)

136. The action of sulfur on cement in the tropics. A. BRUCE. *J. Soc. Chem. Ind.*, **40,** 240T(1921).—Earthenware pipes, laid in Colombo, with cement and a ring of "galanack," and disused for several years showed longitudinal and circumferential cracking. The cement had altered in appearance to that of a white plastic putty and the "galanack" lost its original structure. Analyses of the cement at different ages show increase in SO_4 and loss on ignition, and decreases in lime, iron and alumina and sol. SiO_2. The exact conditions for the change depend more on the manner of application of the galanack, while soil factors are negligible. Galanack is a mixt. of S, tar and oil. W. H. BOYNTON (*C. A.*)

137. Determination of available lime in quicklime and hydrated lime. ALICE I. WHITSON. *Chem. Met. Eng.*, **25,** 740(1921).—Work done at the Bur. of Standards shows that the Scaife method is satisfactory for the detn. of available CaO. The procedure recommended is as follows: Place 1.4 g. of the powdered sample in 200 cc. of hot water and boil 3 min. Add phenolphthalein and titrate slowly with *N* HCl until the color is discharged and does not reap-

pear within 2 sec. Repeat the expt. using a liter graduated flask carrying a 1-hole stopper fitted with a short glass tube drawn out to a point. Cool and add, drop by drop, within 5 cc. of the vol. of HCl required in the preliminary expt. Break up any small lumps with a flattened stirring rod, dil. to the mark with freshly boiled water, close the flask, mix well and after settling for 30 min. pipet off 200 cc. and finish the titration with 0.5 *N* HCl. The results obtained in the analysis of 5 samples by different operators show remarkable concordance. W. T. H. (*C. A.*)

138. Waste heat installation at cement plant. ANON. *Rock Products*, **24**, No. 23, 13–17(1921).—An illusd. description of a plant at Dallas, Texas. E. H. (*C. A.*)

139. Lime in 1920. G. F. LOUGHLIN AND A. T. COONS. U. S. Geol. Survey, *Mineral Resources of U. S., 1920*, Part II, 178–88(preprint No. 22, published Nov. 3, 1921). E. H. (*C. A.*)

140. A critical review of wet process for manufacture of Portland cement. R. K. MEADE. *Concrete* (Mill Sect.), **18**, 135–143(1921); cf. *C. A.*, **15**, 3732.—M. discusses the number of advantages that the wet process of cement manuf. is usually considered to have over the dry process. His conclusion is that the advantages of the dry process are too marked to warrant the substitution of the wet process for it in most instances and that the adherence of the older and more experienced manufacturers to the dry process has been well founded. The possible saving of the wet process in grinding and drying is much more than offset by the saving of the dry process in fuel, while the advantages claimed for the wet process as to lack of dust and better quality of the product are not borne out by either facts or theories. J. C. WITT (*C. A.*)

141. Shrinkage of Portland cement mortars and its importance in stucco construction. J. C. PEARSON. *Proc. Am. Concrete Inst.*, **17**, 133–47(1921).—(1) Thin mortar slabs, cast in non-absorptive water-tight forms, may show large and irregular vol. changes in the plastic state, depending chiefly upon the distribution and retention of water in the specimens up to the time of final set. (2) The initial vol. changes under these conditions can, therefore, be reduced and controlled within fairly close limits by taking the necessary precautions. (3) The shrinkage which occurs after the mortars have set persists for many months under ordinary lab. exposure, and is more or less characteristic of the mortar mixts. (4) The use of forms with absorptive bases greatly reduces the initial vol. changes, and has a remarkable effect on the shrinkage which occurs after the mortars have hardened. With dry, or slightly wet bases, the characteristic shrinkage is reduced by 25–50% of the shrinkage of similar mortars in non-absorptive forms, whereas with satd. absorptive bases the shrinkage tends to exceed that of similar mortars in non-absorptive forms. (5) The results of the investigation indicate the very important rôle of absorption or "suction" in actual stucco application, and account for the diversity of condition exhibited by the stucco test panels.

J. C. WITT (*C. A.*)

PATENTS

142. Rotary kiln for sintering cement slurry, etc. A. LARSEN. U. S. 1,358,759; U. S. 1,358,760; U. S. 1,358,761, Nov. 16. (*C. A.*)

143. Cement mixture. E. R. STOWELL. U. S. 1,364,004, Dec. 28. A mixt. adapted for manuf. of light brick or tile is formed of coal ashes 50, Na silicate 12, ground talc 8–10 and Port. cement 5–10 parts. The mixt. may be used as a plaster or floor covering. (*C. A.*)

144. Insulating metallic layers. J. J. ZWERLING. U. S. 1,363,074, Dec. 21. Layers of metal such as parts of elec. heating devices (*e. g.*, irons) are insulated from each other by a coating of Na silicate soln. carrying inert material such as SiO_2 or carborundum in suspension when applied and to which is added, after its placement on the metal, additional inert material such as SiO_2 in granular form. (*C. A.*)

145. Silicate cements. W. CARPMAEL. Brit. 168,659, June 4, 1920. Cements for dental and other purposes consist of a base such as Mg or Be oxide mixed with a soln. of hydrolyzed org. Si compd. contg. a high per cent of silicic acid. The org. Si compd., *e. g.*, tetramethyl silicate or a condensation product thereof, may be hydrolyzed by H_2O or dil. acid, either alone or in the presence of P_2O_5 or an alcoholate of an alk. earth metal or of Mg or of Al or both. Examples of prepns. are given. (*C. A.*)

146. Paints; cements. F. BENSA. Brit. 147,800, July 9, 1920. Pyrite ashes are freed from H_2SO_4, pulverized, freed from H_2SiO_3 and ground with linseed oil to form a rust-preventing cement. A paint is obtained by dilg. the pasty cement with boiled linseed oil. (*C. A.*)

147. Purifying molten slag. J. LUND. U. S. 1,366,398, Jan. 25. Molten slag is purified in order to render it suitable for *cement manuf.* or other uses by applying heat to the under surface of slag, *e. g.*, in a horizontal rotary furnace containing molten Fe, while at the same time treating the upper surface of slag with basic or acid ingredients to adapt it for its particular intended use. (*C. A.*)

148. "Artificial stone." M. JUNGHANDEL. U. S. 1,363,879, Dec. 28. Cement is mixed with an aggregate of elastic capsular material such as calcined rice hulls in order to form a material suitable for building purposes having good insulating properties against heat and sound. (*C. A.*)

149. Coloring cement surfaces. L. A. AND A. J. SANDERS. U. S. 1,364,587, Jan. 4. Surfaces comprizing hydraulic cement and rendered alk. by the presence of lime are colored by treatment with an aq. soln. of a sulfate or other salt or Cu, Fe, Zn, Ni or Pb. (*C. A.*)

150. Hydraulic cement and alkali from natural silicates. E. W. JUNGNER. U. S. 1,357,873, Nov. 2. Liberation and volatilization of alkali on heating a mixt. of lime and feldspar or similar mineral substances is facilitated by adding to the charge about 4% or more of carbonaceous material such as coal, charcoal or sawdust, in finely divided condition. On heating the materials to 1250–1450°, K_2CO_3 is volatilized and a cementitious residue obtained. No Ca salts of inorg. acids are used (except $CaCO_3$ which is converted into lime in the initial stage of heating of the charge). (*C. A.*)

151. Building material from plaster of Paris. M. BAER. U. S. 1,357,375, Nov. 2. A building material especially adapted for use in ship-building is formed of plaster of Paris mixed with chips or particles of wood and metal. (*C. A.*)

152. Cement clinker and by-products. S. B. NEWBERRY. U. S. 1,366,479, Jan. 25. A finely ground mixt. of raw cement materials and carbonaceous fuel is heated by external heat of the gaseous products of combustion of a subsequent stage of calcination of similar material, the condensible products volatilized from the fuel are collected and recovered, and the mixt. is finally calcined by the combustion of the fixed C of the fuel and of gas volatilized from the fuel. (*C. A.*)

153. Cement. S. MATSUO. U. S. 1,367,984, Feb. 8. Hot Port. cement clinker is added to sand which has been washed with HCl while the sand is still wet and the mixt. is cooled and pulverized to obtain a cement which is resistant to brine. (*C. A.*)

154. Recovering potassium compounds in cement manufacture. C. CATLETT. U. S. 1,354,727, Oct. 5. Recovery of K. compds. in treating a Portland cement mixt. (which may contain feldspar to increase the K content) is facilitated by the addition to the mixt. of 1–5% of a set Ca oxychloride compn. of the sorel cement type. Sufficient of the latter is used to supply Cl to combine with the K to be recovered. The volatilized K values leaving the kiln with the dust may be recovered by simple subsidence, use of wet or dry filters or by elec. pptn. The recovered material may be used as a fertilizer directly or may be leached for the recovery of K compds. in crystd. form. The use of Ca oxychloride is stated to have the advantage over NaCl that the fume and gases produced are much more readily recovered by elec. pptn. and no detrimental effect on the cement clinker is produced. Oxychlorides of Mg and Zn also may be used. The various oxychlorides (including a product formed by treating bittern with $Ca(OH)_2$) may also be used for treating feldspar to produce sol. K compds., with or without simultaneous use or $CaCO_3$, $CaSO_4$ or other auxiliary substances. (*C. A.*)

155. Plastic coating material containing cement. J. C. DOBBINS. U. S. 1,355,131, Oct. 12. A coating material in paste form, adapted for use on walls or fabrics, is formed of Portland cement 100, hydrated lime 13, a coloring material and mica 1.3 parts, H_2O and Na silicate soln. (*C. A.*)

156. Asbestos cement building material. R. V. MATTISON, JR. U. S. 1,355,406, Oct. 12. An asbestos cement suitable for building bricks, roofing or flue linings is formed of Portland cement and finely ground serpentine. The serpentine used contains microscopic fibers of asbestos and a considerable propn. of ground quartz. (*C. A.*)

157. Building block. F. J. KRAMER. U. S. 1,363,045, Dec. 21. A mixt. for making building blocks is formed of pulverized furnace slag 79.8, cement 20, $KMnO_4$ 0.175 and HF 0.025% mixed with H_2O. The $KMnO_4$ facilitates hardening and the HF prevents discoloration. (*C. A.*)

See Abs. 110.

ACTIVITIES OF THE SOCIETY

Minutes of the Meetings of the Board of Trustees

February 27th to March 2nd, 1922

Report of the Committee on Publications:

Voted to accept the recommendation that the *Journal* be increased from eighty-five to one hundred pages per month.

Voted to exchange the *Journal* for other periodicals of equal value, and to subscribe for those of less value, when needed by the editor.

Voted that instructions to contributors to the *Journal* be compiled and distributed.

Voted that fund for expenses of a booth at the Chemical Exposition be omitted from the budget

Voted that the policy of not paying expenses of officers of divisions to meetings, unless specifically delegated by the President, be confirmed.

Voted to request a report from the Committee on Publications and one from the Secretary on the feasibility of soliciting advertising from the Secretary's office.

Voted that the editorial work of the *Journal* be transferred to the office of the Secretary, the Secretary to be Editor for the present year.

Voted to confirm the Board of Associate Editors as appointed.

Voted that the question of handling the *Journal* and the *Bulletin* be referred to the Committee on Publications and the Editor, with power to make definite decision.

Voted to accept resignation of Mr. F. H. Riddle as Trustee.

Voted to appoint Mr. F. B. Ortman as Trustee, to serve the unexpired term of Mr. Riddle.

Voted that list of nominations for active membership be submitted to Board for a vote by mail.

Voted to hold the 1923 annual meeting of the Society in Pittsburgh.

Voted to hold the 1922 summer meeting in Montreal and vicinity.

Voted that on request for loan of cuts used in the *Journal*, electro plates be made at the expense of those requesting, with the understanding that all possible assistance in reprinting articles should be given.

Voted that reprints of the report of the Committee on Standards be made, to be supplied at a rate to be fixed, leaving the distribution of free copies to the discretion of the Secretary.

Voted to continue the contribution of $50 in support of the publication of the Annual Tables of Constants.

Voted to refer the revision of the price of complete sets of the Transactions to the Committee on Publications.

Voted that the Committee on Publications take up the matter of papers in the *New Jersey Ceramist*, with the Committee on Publications thereof.

Voted to accept the report of the Committee on Budget as follows:

ESTIMATED INCOME

Membership			
Individual (1700)		$12,750	
Corporation (250)		6,250	
Subscriptions		1,500	
Advertising		17,700	
Volumes, Sale		1,200	
Seger and Index		80	
Interest		400	$39,880

ESTIMATED EXPENSE

Publication			
Printing	$15,000		
Abstracts	400		
Reprints	600		
Salaries	1,500		
Office Expense	500		
Year Book	575	18,575	
Advertising Commission		4,185	
Secretary's Office			
Salaries	7,820		
Clerical Help	1,000		
Bulletin			
Traveling	1,800		
Office Expense	2,000	12,620	
Divisions		700	
Committees		400	
Meetings		1,500	
Miscellaneous		900	
Shrinkage		1,000	$39,880

Report of Committee on Budget

The receipts are based upon an estimated increase in membership of 100 Corporation and 180 Associate members.

In the opinion of the Committee the estimated expenses for publication can be materially reduced by changing the shape of the *Journal* and the size of type used. This is suggested to the Committee on Publication for their consideration.

The present expense of securing advertising can be lowered by having our own organization solicit the same.

(Signed) F. H. RIDDLE, *Chairman*,
ROSS C. PURDY,
R. K. HURSH.

Voted to confirm the appointment of representatives on committees of the A. S. T. M. as follows:

Proposed Representative on A.S.T.M. Committees

A-1 on Steel, Sub-Committee XIX on Steel Sheets—R. R. Danielson
C-1 on Cement—Robert W. Jones
C-3 on Brick—Roy A. Horning
C-4 on Clay & Cement Sewer Pipe—Fred L. Dickey
C-5 on Fireproofing—Geo. A. Loomis
C-6 on Drain Tile—J. L. Childs
C-7 on Lime—A. A. Silverman
C-8 on Refractories—Wm. E. Dornbach
C-10 on Hollow Building Tile—C. F. Tefft
C-11 on Gypsum—Geo. A. Bole
D-11 on Electrical Insulating Materials—Walter Hull
D-10 on Shipping Containers—E. Ward Tillotson
D-14 on Screen Wire Cloth—W. D. Richardson

Voted to confirm appointment of the standing committees as follows:

Proposed Standing Committees for 1922

Committee on Research:
Dr. Wm. M. Clark, *Chairman*
E. W. Washburn
Paul E. Cox
Albert V. Bleininger
and one from each division

Committee on Standards:
Walter E. Hull, Chairman
(*a*) Definitions: A. S. Watts
M. F. Beecher
A. F. Greaves-Walker
(*b*) Raw Materials: D. W. Ross
M. C. Booze
E. C. Hill
(*c*) Standardization of Tests:
All appointed by Divisions
(*d*) Standardization of Products:
All appointed by Divisions

Committee on Geological Surveys:
T. Poole Maynard, *Chairman*
Robert W. Jones
H. Ries

Joseph Keele
Hewitt Wilson

Committee on Data:
To be appointed by Divisions

Committee on Ceramic Education:
Not yet provided for by Constitution

Committee on Rules:
T. A. Kleinfelter, *Chairman*
R. L. Clare
A. S. Walden
B. T. Sweely
J. L. Crawford
and Chairmen of Committees on Rules in Divisions

Committee on Publications:
R. H. Minton
E. Ward Tillotson
Chester H. Jones
H. F. Staley
R. C. Purdy

Committee on Papers and Program:
R. D. Landrum
and Secretaries of Divisions

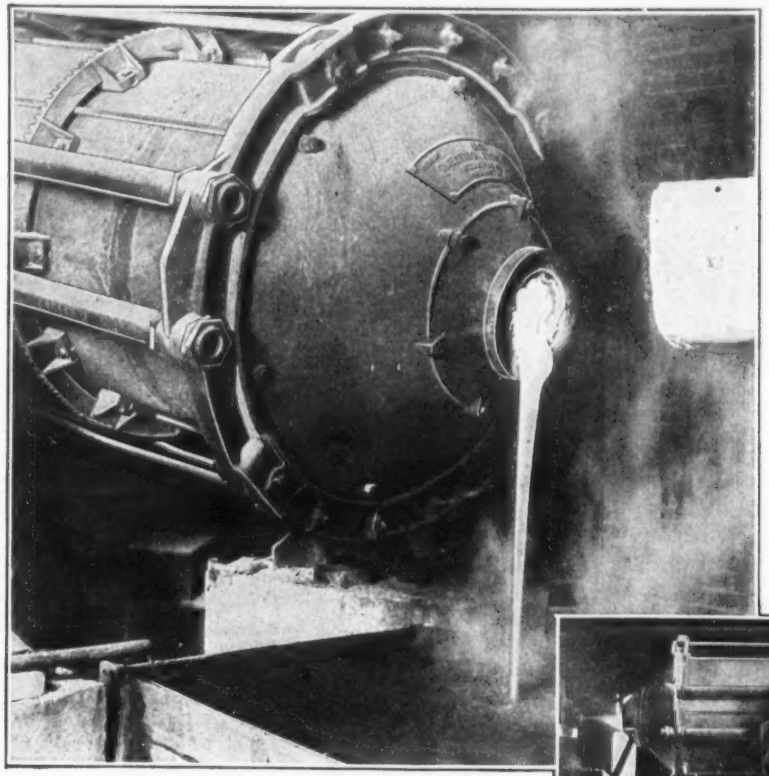
Committee on Membership:
E. P. Poste, *Chairman*
O. O. Bowman, 2nd
Charles Sebring
D. F. Stevens
Frederick Stanger
and Chairmen of Committees on Membership in Divisions

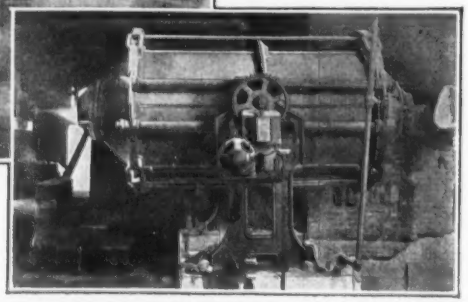
Committee on Sections and Divisions:
J. B. Shaw, *Chairman*
Robert Back
Wm. E. Dornbach
Geo. P. Fackt
Major E. Gates
and Chairmen of Divisions

Voted to recommend to the Committee on Rules that the Constitution and By-laws be amended, to the effect that no paid officer or employee of the Society shall have a vote upon any committee to which he is appointed by virtue of his position.

Voted to interpret literally the article in the Constitution which states that all publications of the Society come under the general supervision of the Committee on Publications.

BELLEVILLE, ILLINOIS





These illustrations made from photographs taken in the plant of Ingram-Richardson Mfg. Co., Beaver Falls, Pa.

12-21

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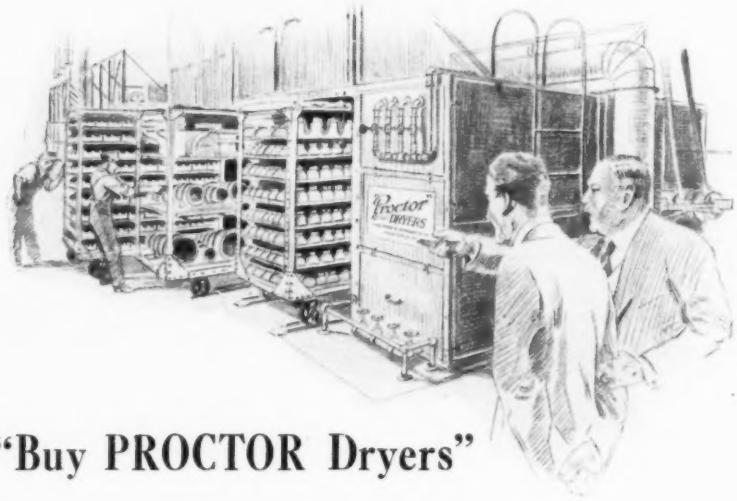
BELLEVILLE. ILLINOIS



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Auger Machines
Chambers Brothers Co.
Crossley Machine Co.
Manufacturers Equipment Co.

Automatic Cutters
Chambers Brothers Co.

Automatic Stove Rooms
Philadelphia Drying Mch. Co.

Ball Mills
Abbé Engineering Co.
Crossley Machine Co.
Hardinge Co.
Mueller Machine Co., Inc.

Bituminous Coal
Seaboard Fuel Corp.

Blowers (Pressure)
Abbé Engineering Co.

Boilers
Nashville Industrial Corp.

Bolting Cloth
Abbé Engineering Co.

Brick Making Machinery
Chambers Brothers Co.

Business Education
Alexander Hamilton Institute

Caustic Soda
Pennsylvania Salt Mfg. Co.

Ceramic Plant Equipment
Abbé Engineering Co.
Chambers Brothers Co.
Crossley Machine Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc.
Philadelphia Drying Machinery Co.
Proctor and Schwartz, Inc.

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Drakenfeld Co., B. F.
Harshaw, Fuller and Goodwin Co
Paper Makers Importing Co., (Inc.)
Roessler and Hasslacher Chemical Co.
Vitro Mfg Co.

Clay (Ball)
Johnson Porter Clay Co.
Potters Supply Co., The

Clays (China)
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Drakenfeld and Co., B. F.
Paper Makers Importing Co., (Inc.)
Roessler & Hasslacher Chemical Co.

Clay (Electrical —Porcelain)
Edgar Brothers Co.
Johnson Porter Clay Co.
Paper Makers Importing Co., (Inc.)

Clays (Enamel)
Edgar Brothers Co.
Johnson-Porter Clay Co.

Clay (Fire)
Edgar Brothers Co.
Paper Makers Importing Co , (Inc.)

Clay (Potters)
Johnson-Porter Clay Co.

Clay (Sagger)
Edgar Brothers Co.
Johnson Porter Clay Co.
Paper Makers Importing Co , (Inc.)
Potters Supply Co., The

Clay Handling Machinery
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc.

Clay Miners
Edgar Brothers Co.
Johnson Porter Clay Co.

Clay Washing Machinery
Crossley Machine Co.
Mueller Machine Co , Inc.

Clay Working Machinery
Abbé Engineering Co.
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co
Mueller Machine Co , Inc.

Coal-(Bituminous)—
Seaboard Fuel Corp.

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Harshaw, Fuller and Goodwin Co.
Roessler and Hasslacher Chemical Co.
Vitro Mfg. Co.

Conditioning Machinery
Philadelphia Drying Machinery Co.

Conical Mills
Hardinge Co.

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Crossley Machine Co.
Hadfield-Penfield Steel Co.
Philadelphia Drying Machinery Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc

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Charles Engelhard, Inc.

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Abbé Engineering Co.
Chambers Brothers Co.
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Hardinge Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc.

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Harshaw, Fuller and Goodwin Co.
Roessler and Hasslacher Chemical Co
Vitro Mfg. Co.

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Chambers Brothers Co.
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc.

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Manufacturers Equipment Co.

Dryers (China Ware—Porcelain)
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Proctor and Schwartz, Inc
Russell Engineering Co.

Dryers (Radiated Heat)
Manufacturers Equipment Co.

Drying Machinery
Crossley Machine Co.
Philadelphia Drying Machinery Co,
Proctor and Schwartz, Inc.
Manufacturers Equipment Co

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Wilson-Maeulen Co.

Electrical Porcelain Machinery
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Mueller Machine Co , Inc.

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Enameling Furnaces
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U. S. Smelting Furnace Co.

Enameling Muffles
Parker-Russell Mining & Mfg. Co

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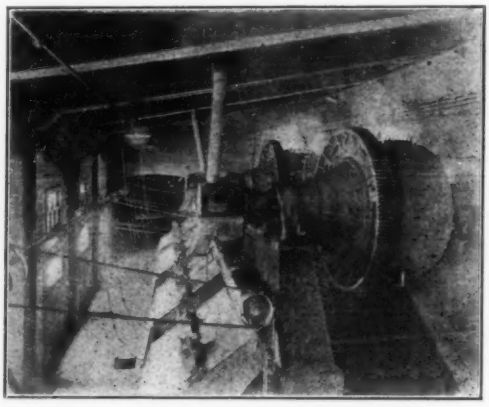
Enamels, Porcelain
The Porcelain Enamel & Mfg. Co.

Engineering Service
Abbé Engineering Co.
Crossley Machine Co.
Chambers Brothers Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co.

Equipment (used)
Nashville Industrial



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Proctor and Schwartz, Inc.
Russell Engineering Co.

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Nashville Industrial Corp.

Extruding Machines (Lab. Use)
Chambers Brothers Co.

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O'Brien and Fowler
Penland Feldspar & Kaolin Co.
Roessler & Hasslacher Chemical Co.

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Abbé Engineering Co.
Crossley Machine Co.
Mueller Machine Co., Inc.

Fire Brick
Parker-Russell Mining & Mfg. Co.

Fuel
Seaboard Fuel Corp.

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Parker-Russell Mining & Mfg. Co.
The Porcelain Enamel & Mfg. Co.
The Surface Combustion Co.

Gold
Harshaw, Fuller and Goodwin Co.
Roessler and Hasslacher Chemical Co.

Glazes and Enamels
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Roessler and Hasslacher Chemical Co.
Vitro Manufacturing Co.

Ilmenite
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Impervite (Refractory and Hard Porcelain)
Charles Engelhard, Inc.

Iron (Enameling)
United Alloy Steel Corp.

Jar Mills
Abbé Engineering Co.

Jiggers
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Mueller Machine Co., Inc.

Kaolin
Edgar Plastic Kaolin Co.
Harshaw, Fuller and Goodwin Co.
Penland Feldspar & Kaolin Co.
Roessler & Hasslacher Chemical Co.

Kryolith
Pennsylvania Salt Mfg. Co.

Laboratory Equipment
Nashville Industrial Corp.

Laboratory Mills
Abbé Engineering Co.
Crossley Machine Co.

Metals (Porcelain Enameling)
United Alloy Steel Corp.

Mills (*See under Ball Mills*)
(*See under Pebble Mills*)

Minerals
Drakenfeld and Co., B. F.
Harshaw, Fuller and Goodwin Co.
Roessler and Hasslacher Chemical Co.

Mixing Machines
Chambers Brothers Co.

Muriatic Acid
Harshaw, Fuller and Goodwin Co.
Pennsylvania Salt Mfg. Co.
Roessler and Hasslacher Chemical Co.

Oil (Die)
Best Oil Works

Oil (Lubricating)
Best Oil Works

Oil (Sagger)
Best Oil Works

Operators (Coal)
Seaboard Fuel Corp.

Oxides
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Harshaw, Fuller and Goodwin Co.
Paper Makers Importing Co., (Inc.)
Pennsylvania Salt Mfg. Co.
Roessler and Hasslacher Chemical Co.

Pans (Wet and Dry)
Chambers Brothers Co.
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc.

Paris White
Potters Supply Co., The

Pebble Mills
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Crossley Machine Co.
Hadfield-Penfield Steel Co.
Hardinge Co.
Mueller Machine Co., Inc.

Pins
Potters Supply Co., The

Plate Feeders
Chambers Brothers Co.
Crossley Machine Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co.

Porcelain Balls and Lining
Abbé Engineering Co.

Porcelain Enameling Plants and Equipment
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Porcelain Enameling Service, Practical
The Porcelain Enamel & Mfg. Co.

Porcelain Enamels
The Porcelain Enamel & Mfg. Co.

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Crossley Machine Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc.

Producer Gas Burning Systems
Manufacturers Equipment Co.

Pug Mills
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Crossley Machine Co.
Hadfield-Penfield Steel Co.
Manufacturers Equipment Co.

Pulverizing Machinery
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Crossley Machine Co.
Hadfield-Penfield Steel Co.
Hardinge Co.
Manufacturers Equipment Co.
Mueller Machine Co., Inc.

Pulverizing Mills
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Crossley Machine Co.
Hadfield-Penfield Steel Co.
Hardinge Co.
Mueller Machine Co., Inc.

Pumps
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Mueller Machine Co., Inc.

Pyrometers (Indicating)
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Wilson-Maeulen Co.

Pyrometers (Recording)
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Montgomery Porcelain Products Co.

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Refractory Materials
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Rutile
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Parker-Russell Mining & Mfg. Co.
Silex Lining
Abbé Engineering Co
Hardinge Co.
Selenite of Sodium
Drakenfeld and Co., B. F.
Vitro Mfg. Co.
Smelters
Parker-Russell Mining & Mfg. Co.
U. S. Smelting Furnace Co.
The Surface Combustion Co
Stilts
Potters Supply Co., The
Stoneware (Chemical)
Nashville Industrial Corporation
Sulphuric Acid
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Harshaw, Fuller and Goodwin Co.
Pennsylvania Salt Mfg. Co
Roessler and Hasslacher Chemical Co
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Charles Engelhard
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Crossley Machine Co.
Mueller Machine Co., Inc.
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Montgomery Porcelain Products Co.
Tubes (Pyrometer)
Charles Engelhard, Inc.
Montgomery Porcelain Products Co.
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Abbé Engineering Co
Tunnel Kilns
Russell Engineering Co
Vacuum Pumps
Abbé Engineering Co
Whiting
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Harshaw, Fuller and Goodwin Co.
Roessler and Hasslacher Chemical Co.
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Zirconia
Vitro Mfg. Co.
Zirconium Silicate (Fire Cement)
Buckman and Pritchard, Inc.
Zirconium Silicate (Refined)
Buckman and Pritchard, Inc.

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Membership Committee

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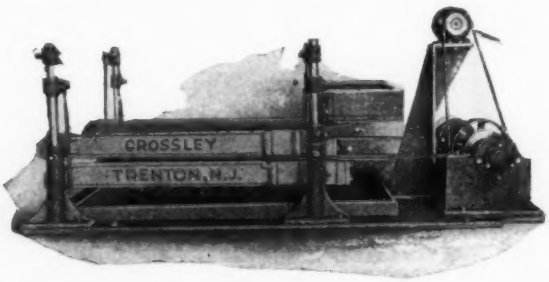

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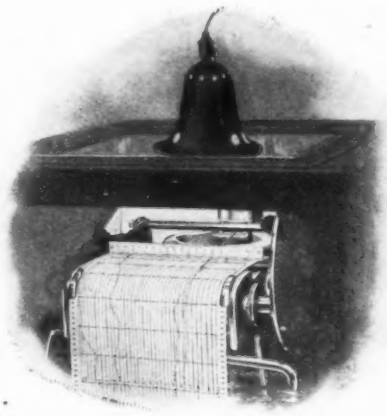

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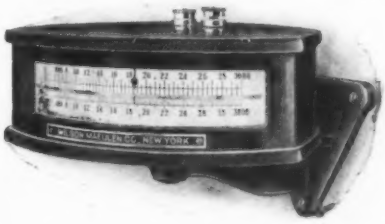

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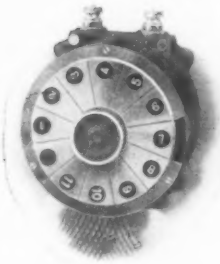

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5-22

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EQUIPPED FOR KEROSENE OIL,

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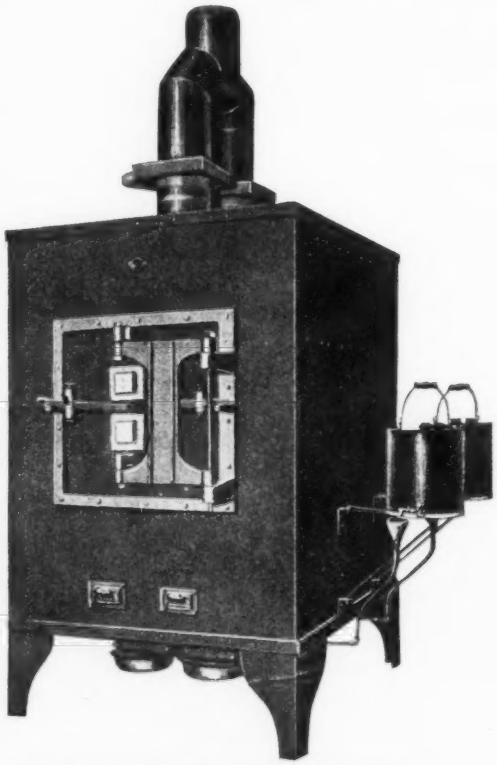

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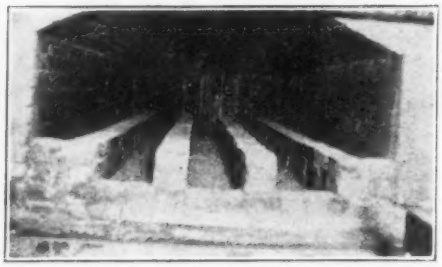

Unretouched photograph of interior of Surface Combustion Enameling Furnace in operation 6 days per week for 16 months with no repairs whatever.

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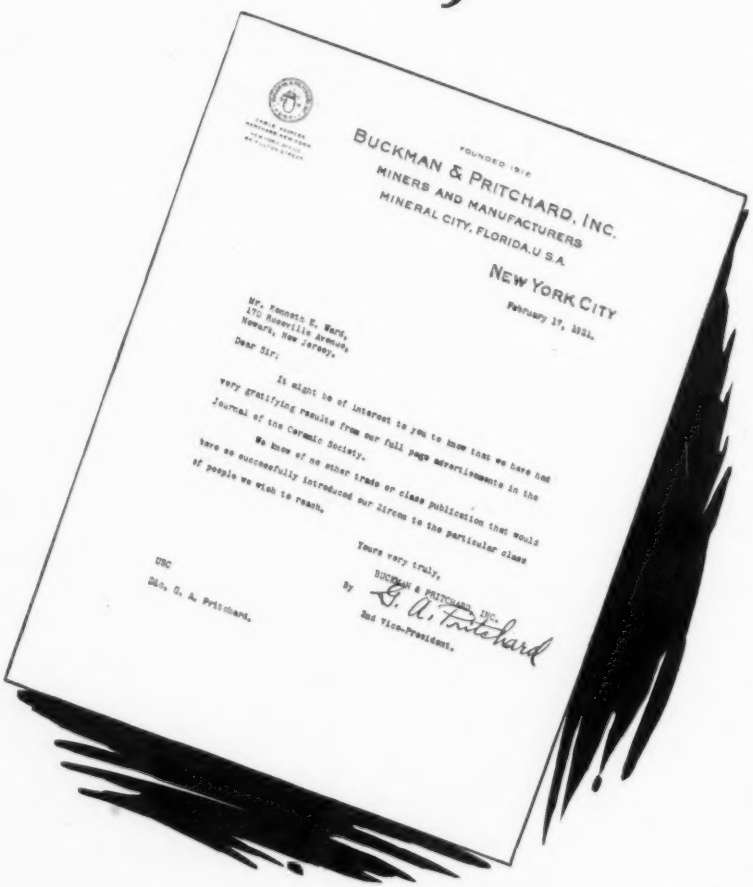

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American Ceramic Society

Year Book
1921 - 22

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PRESIDENTIAL ADDRESS

By Forrest K. Pence

Progress and Policy

We are living in an era of change. There may be those who explain modern tendencies on the basis of discontent or a spirit of restlessness, but the optomistic will interpret the spirit of the times in terms of progress.

More history is being made in months than was previously made in decades and the underlying motive that becomes more and more manifest is the shaping of events to the end that man may be better served. Epoch making events are being recorded, that should bring mankind untold benefits.

The American Ceramic Society has responded in a marked degree to this modern desire for better things. We have been rapidly extending our power for service. An unusually large number of new measures have been adopted during the past year. The movement leading up to these developments has been increasingly apparent during recent years.

The employment of a full time secretary, establishing of a contact with industrial associations, the creating of a coordinating service council, the forwarding of the program of co-operative research, the authorization of a bi-weekly bulletin, these and other matters have been put into effect. This has involved much labor and perhaps, at times, some confusion, but considering the mass of detail that has been acted upon, the board and committee members have moved with remarkable dispatch and efficiency. However, we must be careful not to move rashly and without due circumspection.

Many of the measures recently adopted were recommended after careful consideration by the executive conference which was called at New York City last September. Some of the recommendations of the conference were not adopted after further consideration by the board of trustees. So that the element of conesrvation has not been left out.

Due regard has also been given to financial matters. An audit by an expert accountant was obtained so that our assets are properly classified and accredited. Accounts and payments have been assigned to the year to which they properly belong. In the course of this convention a committee will make recommendations to the board

with reference to a budget system, which has become a necessary part of our financial procedings. Our financial statement for the year shows a slight gain, but some of the items are not satisfactory and close study of these will need to be given.

Then the increasing of our membership list has been constantly a part of the plan. Although the attention of the officers and committees has been largely directed to problems within the organization, (looking forward to the time when our program would be sufficiently formulated to justify the launching of a large membership campaign), the society has maintained its normal growth throughout the year. Great credit for this is due Mr. Riddle and the membership committee. They have already laid the ground work for the coming year. In fact, during the past month, literally thousands of communications have been sent out conveying to prospective members some idea of the hopes and ambitions to serve that the American Ceramic Society is fostering. A much larger increase in membership in the near future can be confidently anticipated.

That the Society will apply itself wisely to the tasks ahead would be considered as assured by one in intimate contact with those who have been most active in the affairs of this expansion program. Earnest thought and unselfish sincerity is constantly being asserted.

I must express my deep appreciation for having had the privilege of a share in this work. To the board, the retiring secretary, the full time secretary and the many other officers and committee members who have contributed so much during the past year, I am sure the membership joins me in tendering most hearty thanks.

In this connection permit me to say that no one need fear that the Society will become a "one man society" because we have a full time secretary. The interest of the other officers has been just as keen, I think in some cases even more so, since we have created this office. By the activity and energy of Mr. Purdy working through our present organization, the officers and membership are kept in close touch with issues before us. It would be superfluous, therefore, for me to enter into detailed discussion of the Society's affairs. You are already advised.

May I present to you however a few remarks on the subject of the general policy of the Society in its enlarged field. I have been in a favorable position in recent months to gather some impressions, both within the Society proper and with allied organizations, which I trust may be of value.

Conditions have changed somewhat since the Society was founded. At that time the membership represented a group who sought an

opportunity to exchange ideas, and to publish information that would be helpful in spite of the general practice of secrecy that was attempted in the industries. We have now reached a stage in which it becomes the problem of the Society to so apply its original purpose and policy as to satisfy the desire of industrial groups to co-operate in the exchange of information and the study of problems common to the industry.

The industries are seeing the economic value of joining together in research studies. Then too there can be no objection to co-operation of this sort while, on the other hand the government is frowning rather severely upon some forms of economic agreement. Co-operative research affords the industrial association a real raison d'aitre.

Much discussion has been offered pertaining to the functions of the American Ceramic Society in this co-operative activity. Some confusion of ideas as to how the Society can best serve, and doubtless some difference of opinion as to the modus operanda of applying the service continues to exist.

Let us recognize that the American Ceramic Society affords first of all a forum where contributions for Ceramic knowledge may be presented and discussed. Such contributions being carefully edited, are then made available to all interested parties through the medium of the Society's publications. This was the purpose for which the Society was originally organized and remains today the fundamental feature of its activity.

The organization of sections and divisions with their various committees was only to facilitate the working out of that program, the idea being that investigative work would be thus encouraged and discussion stimulated. Our publications would be correspondingly enriched.

This has been the result until now there are a number of co-operative investigations being made, some under the auspices of committees within the American Ceramic Society divisions, and some under the auspices of industrial group committees practically all of whom are American Ceramic Society members.

In the case of some of the divisions, all of the industries of the division are so closely allied that a co-operative program under an American Ceramic Society Divisional Committee has worked out in a practical way. In some divisions there has been a tendency for more specialized groups to undertake co-operative investigation on their own initiative.

The Society obviously could not form a division for every industrial group so that there would be certain group or association

activities carried on as such. There are also economic reasons for this and the Society is at all times to be congratulated that its influence has encouraged such activity wherever it exists.

Such investigations having been made, the Society can render the further valuable service of contributing to the discussion of such matter as would be of general interest to the American Ceramic Society division under which an industrial group would be classified and of making such matter available through our publications. The logic of such a proposition would certainly appear sound from the standpoint of good business judgment.

Take the recent movement within the United States Potters Association as a case in point. This Association recently appointed a committee of research, of which I have the privilege of being a member. This committee has already entered upon a program of co-operative research. It will be a case where so called competitors work together for the common betterment. That is a splendid step for the United States Potters Association to take, and would it not be of very great value to the potters to have the results of these co-operative investigations presented in our White Wares Division where discussion could be offered by those possssing information along similar lines in similar industries. Then with this subject matter edited and published by our Society, reprints would be furnished and a very economic method of distributing the information to the membership of the Potters Association would be offorded. Since such information is to be made the common property of those engaged in the same industry, it would be thus possible to secure the very great advantage of presenting it before the ceramic industries in general and those of the white wares group in particular. The additional information upon the problems in question, as a result of this discussion and publication through the medium of the American Ceramic Society, would result in great benefit to the association in particular and the ceramic industries in general. The same course of reasoning will apply to any or all of the industrial groups engaged in ceramic manufacture.

It is the industries that must finance these group investigations and it is the particular function of the American Ceramic Society to encourage and promote such activities and finally to present a medium of discussion and publication that will be so valuable that no industrial organization of ceramic nature can afford to neglect to avail themselves of it.

The organization of the Society and its divisions stands ready to serve, and to a large degree, is already serving, the ceramic industries in various programs of research. While the American Ceramic Society does not presume to dictate a program of research

to any industry, we invite and urge the ceramic industries of our various divisions to use our divisional research committees in forwarding any proposed co-operative program.

These committees may serve in such instances in an advisory capacity or may have actual direction of the work. The practical operation of this would be made possible by the committee members being chosen from those corporations that desire to join in such co-operative work and the whole movement being backed in a substantial way by the corporations directly benefited.

The operation of the Society as a forum of discussion and medium for publication of results obtained in such instances would make the service complete. We believe that as the possibilities of this program are more generally comprehended, the ceramic industries and the American Ceramic Society will work in more intimate contact in the forwarding of the Ceramic Arts and Sciences.

As the Amercan Ceramic Society is termed a technical organization, so are our Ceramic industries, in a large sense, technical organizations. The factory is a research laboratory in which better results are constantly sought. We, therefore, interpret our relation with the ceramic industry in terms of service. Organized industry is the foundation stone of our social and economic structure. Let our ceramic industries and the American Ceramic Society be linked together in this program of service for the common good.

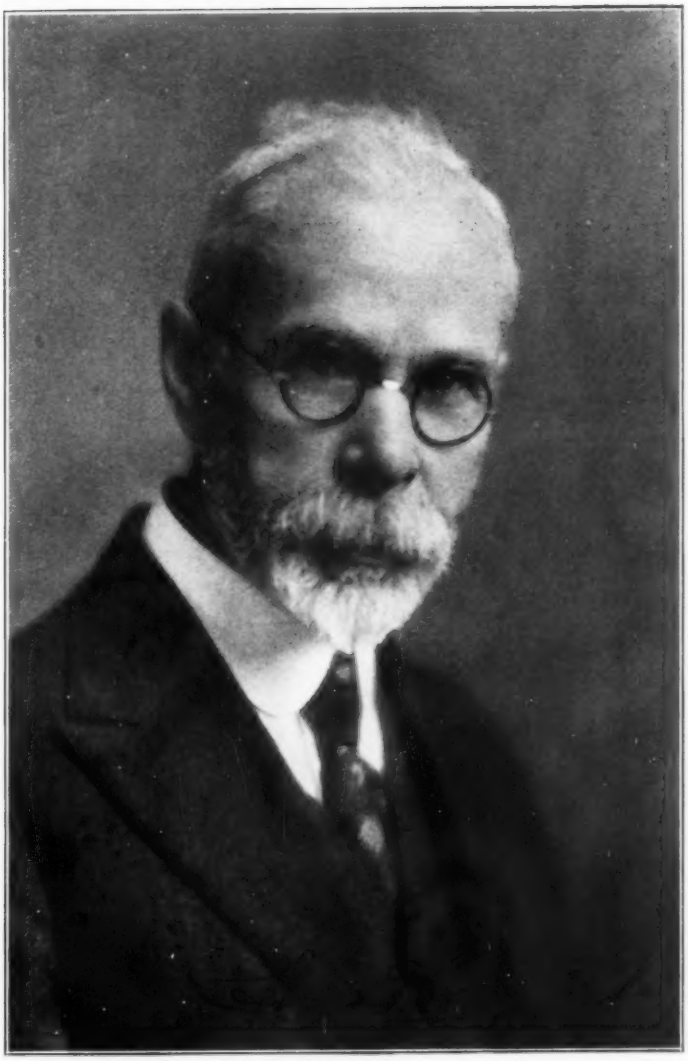
IN RECOGNITION

Charles Fergus Binns, the retiring Secretary of the American Ceramic Society, was born in Worcester, England, October 4, 1857. His young manhood was spent in the Worcester Royal Porcelain Works, of which his father was manager. Mr. Binns Jr., established and equipped at this works the first laboratory in England to attempt scientific plant control. For a few years he was in charge of the London sales office of this company but later returned to Worcester to manage the plant. In 1897, having a vision of opportunity in the rising prestige of ceramic America, he undertook a lecture tour in this country and in 1898 he settled in Trenton, becoming connected with the Lenox China Company. His natural love of art led him to accept the directorship of the Trenton Art School, where he taught at night after working in the pottery laboratory all day.

This work had a happy sequel in that, through it, he was suggested in 1900 for the position of director of the newly authorized New York State School of Clay-Working and Ceramics, to be situated at Alfred University, Alfred, New York. The difficulties pursuant to the establishment of an efficient department of ceramics in a small college were courageously undertaken and pushed to successful accomplishment.

As a ceramic artist and also as a critic of artistic ware, Professor Binns has a national reputation. Many of the leaders in the production of fine pottery in this country have been, at one time or another, students of this inspiring master. He has contributed much to the technical literature by papers and discussions, particularly in the publications of the American Ceramic Society, and he is also the author of several books.

When the American Ceramic Society was in need of a secretary, due to the retirement of Professor Orton, it naturally turned to this man of wide experience and broad sympathy, and the efficient way the affairs of the Society were handled under his guidance is common knowledge. The transitional period through which the Society was passing at this time needed a steady and sympathetic hand at the wheel. We feel that Professor Binns was sent "for such a time as this."



REPORT OF THE BOARD OF TRUSTEES FOR THE YEAR ENDED DECEMBER 31, 1921

The year 1921 has been in some respects the most notable year of the Society's existence. The ordinary routine work has been carried on much as usual with only the additional effort called for by a growing membership, but there have been some important developments. One year ago a committee was appointed to investigate and report fully upon the "functions of the Society, the possibilities of development in co-operation and research with a view to the appointment of a full time secretary." This committee reported in due course and in accordance with their recommendation Mr. R. C. Purdy was, on July 11th, appointed Organizing Secretary for the remainder of the year with the understanding that he should take over the full duties of Secretary on January 1st, 1922.

Ohio State University, through Dean E. S. Hitchcock, having offered to the Society space in Lord Hall free of charge, the offer was gratefully accepted by the Board and Mr. Purdy immediately opened his office there. A report of his particular work will be found elsewhere.

A conference of officials and leaders of divisions and sections was called at the Commodore Hotel, New York, on September 12th, being the week of the Chemical Exposition. The conference was not very largely attended, but a considerable amount of constructive work was done.

The Constitution has been amended, the amendments being passed by the Committee on Rules and adopted by vote of the Society, to provide for:

1. A new membership classification to be known as Industrial Association Members who "must be organized groups of manufacturers, who, being interested in the advancement of ceramic arts and sciences shall make, for this purpose such financial contributions as are provided," these dues are at present fixed at not less than $480 a year.

2. The creation of a coordinating service council to consist of the respective chairmen of the standing committees on Research, Standards, Geological Surveys and Data, with the Secretary as chairman.

The Society secured and furnished a booth at the Chemical Exposition and the conveniences thus afforded were extensively used by the members and their friends. The Assistant Secretary was on duty the whole week. On Ceramic Day a well attended meeting was

held in the library of the Armory and a program of papers was carried out. Mr. John G. Jones of the Alexander Hamilton Institute delivered an inspiring address.

The new divisions mentioned in the last report, those on Heavy Clay Products, White Wares, and Art, have been duly organized and show promise of effective service.

The Committee on Publications has given close attention to the Journal, the quality of which has been substantially improved under the editorial care of Dr. E. W. Washburn with his board of Associate Editors. Due largely to the effective work of Mr. Leroy W. Allison, as advertising manager, the receipts from advertising have been increased considerably. On May first, the operative printers declared a general strike and the publication was consequently greatly delayed. During the summer the situation improved, but the arrears of date have not been entirely overcome.

The Nominating Committee as organized according to the revised rule carried through its work without difficulty. Every division and every section but one was represented and served, with the two past presidents, and the Secretary as chairman without vote. Two ballots were taken on all the officrs and three on one of them. It is believed that in this action the whole Society has been represented.

The membership has increased from 1348 to 1489 and the details of gains and losses will be given in the report of the Membership Committee.

The Summer Meeting was held on July 26-28 at Canton, Alliance, Sebring and East Liverpool, Ohio. There was a very large attendance and the general opinion was that the meeting was the best ever held in the summer. An efficient local committee under the chairmanship of Mr. Ira A. Sproat was tendered hearty resolutions of thanks.

The Board places on record its appreciation of the generosity of the Gill Clay Pot Company who on their own initiative and at their own expense of about $50 issued a circular questionnaire to the members of the Society with regard to the proposed meeting in England next summer. The negotiations are now being further pursued by the Secretary.

The Board has authorized the payment of fifteen dollars dues to the American Society for Testing Materials, so that the American Ceramic Society may be kept in close touch with the allied committees in that society.

Owing to the increased expense of the engagement of a full time Secretary and the removal and equipment of the office, the Board has found it necessary to realize on the $7000 invested in Treasury

AMERICAN CERAMIC SOCIETY, Inc.
Balance Sheet
December 31, 1921

	Trial Balance		Year 1921		Jan. 1, 1922	
	Dr.	Cr.	Loss	Gain	Assets	Liabilities
Cash in Bank	$ 1,770.51				$ 1,770.51	
Liberty Bonds	8,700.00				8,700.00	
Furniture and Fixtures	783.85				783.85	
Accounts Receivable						
Advertising $1,459.90						
Dues, 1920 185.00						
Dues, 1921 1,034.40						
Publications 741.46						
Reprints 60.15	3,480.91				3,480.91	
Inventories						
655 Bibliographies $ 0.00						
1270 Indexes—10c 127.00						
35,417 Jours.—10c 3,541.70						
351 Trans. P.—$2.50 877.50						
171 Trans. C.—$3.00 513.00	5,059.20	1,084.59			5,059.20	1,084.59
Dues—Prepaid, 1922		479.39				479.39
Journals—Prepaid, 1922						
Divisions	26.27	15.50	14.52			3.75
Art	142.00	145.00	8.55			11.55
Enamel	57.94	163.81		90.29		15.58
Glass	43.86	74.50		18.46		12.18
Heavy Clay Products	70.00	120.00		35.00		15.00
Refractories	22.00	42.00		19.25		75
Terra Cotta	88.08	315.20		198.72		28.40
White Wares		1277.50		1,277.50		
Advertising, 1920		7,864.55		7,864.55		
Advertising, 1921						
Dues	231.00	2,408.00		2,177.00		
Active	596.64	7,324.44		6,727.80		
Associate	335.00	3,202.50		2,867.50		
Corporation		5.82		5.82		
Bibliographies		2.00		2.00		
Directory of Dealers	10.02	257.25		247.23		
Indexes		627.24		627.24		
Interest						
Journals		129.26		129.26		
Vol. 1, 1918		153.72		153.72		
Vol. 2, 1919		203.96		203.96		
Vol. 3, 1920		1,121.95		1,121.95		
Vol. 4, 1921		316.24		316.24		
Reprints		157.50		157.50		
Seger's Writings		1,478.98		1,478.98		
Transactions A. C. S.		149.62		149.62		
Miscellaneous	969.61		969.61			
Advertising Commissions	331.55		331.55			
Committee Expense	851.86		851.86			
Journal, 1920	9,780.15		9,780.15			
Journal, 1921	1,667.27		1,667.27			
Meetings	437.52		437.52			
Miscellaneous	2,322.95		2,322.95			
Office Expense	607.25		607.25			
Reprints	7,447.09		7,447.09			
Salaries	77.47		77.47			
Seger's Writings	1,023.00		1,023.00			
Traveling Expense	213.62		213.62			

Office Expense	607.25		607.25			
Reprints	7,447.09		7,447.09			
Salaries	77.47		77.47			
Seger's Writings	1,023.00		1,023.00			
Traveling Expense	213.62		213.62			
Transactions A. C. S.		18,026.10				18,143.28
Surplus			117.18			
Profit for 1921	$47,146.62	$47,146,62	$25,869.59	$25,869.59	$19,794.47	$19,794.47

THE AMERICAN CERAMIC SOCIETY
Loss and Gain Statement
January 1st to December 31st, 1921

Earned Dues			$11,772.30	
Net Gain on Divisions			338.65	
Bibliographies			5.82	
Dealers' Directory			2.00	
Indexes Collective (Net)			247.23	
Interest			627.24	
Miscellaneous			149.62	
Volumes of Transactions				
Receipts		$1,478.98		
Cost		213.62		
Net Gain			1265.36	
Seger's Collected Writings				
Receipts		157.50		
Cost		77.47		
Net Gain			80.03	
Total				$14,488.25
Journals—1921				
Cost of Publication		9,780.15		
Advertising	$7,864.55			
Less Commission	969.61			
	6,894.94			
Sales	1,121.95	8,016.89		
Net Loss		1,763.26		
Journals 1918-19-20				
Sales	486.94			
Advertising—1920	1,277.50			
	1,764.44			
Cost of Publication 1920	851.86	912.58		
Net Loss all years			850.68	
Reprints				
Cost		607.25		
Receipts		316.24		
Net Loss			291.01	1,141.69
				13,346.56
Expenses				
Salaries			7,447.09	
Office			2,322.95	
Traveling			1,023.00	
Meetings			1,667.27	
" Committees			331.55	
Miscellaneous			437.52	
Total				13,229.38
Net Gain for year				$ 117.18

Certificates, but it is hoped and expected that the enlarged and increased activities will speedily permit an equivalent accumulation of reserve funds.

It is a matter of disappointment to the Board that the Collective Index has not been more generally called for. The edition was printed at an expenditure of nearly sixteen hundred dollars and up to the present time less than three hundred copies have been sold. It would seem that those who possess a set of the Transactions can scarcely afford to dispense with the Index.

The financial report is appended.

AMERICAN CERAMIC SOCIETY, Inc.

Treasurer's Cash Account

January 1, 1921, to December 31, 1921

RECEIPTS

Free balance in bank, January 1, 1921	$ 1,762.50
Dues, earned	11,342.10
Dues, unearned (1922)	1,171.80
Transactions A.C.S. sold	1,145.73
Journals subscriptions, earned	1,508.32
Journals subscriptions, unearned	186.75
Advertisements, 1920	1,277.50
Advertisements, 1921	6,404.65
Reprints	256.09
Seger's Writings sold	150.00
Branner's Bibliographies sold	5.82
Directory of Dealers sold	2.00
Index to Transactions sold	249.75
Meetings	28.50
U. S. Treasury Certificates	7,000.00
Interest	627.24
Miscellaneous	149.62
	$33,268.37

DISBURSEMENTS

Salaries	$ 7,447.09
Publishing Journal for December, 1920	812.41
Abstracts, December, 1920	39.45
Publishing Journla, January to November, 1921	9,520.52
Abstracts, January to October	259.63
Reprints	607.25
Meetings	1,695.77
Index to Transactions	10.02
Dues (charged for lost check and transferred funds)	23.50
Office equipment	256.35
Office expense	2,322.95
Seger's Writings	77.47
Transactions, A.C.S.	213.62
Traveling expense	1,023.00
Advertising Manager's Commissions	969.61
Committee expense	331.55
Division expense	450.15
U. S. Treasury Certificates	5,000.00
Miscellaneous	437.52
	$31,497.86
Balance in Bank	1,770.51
	$33,268.37

AMERICAN CERAMIC SOCIETY, Inc.

Financial Statement

January 1, 1922

ASSETS

Cash in Bank			$ 1,770.51
Liberty Bonds, fourth issue			8,700.00
Accounts Receivable—			
Advertising		$ 1,459.90	
Dues, 1920		185.00	
Dues, 1921		1,034.40	
Publications		741.46	
Reprints		60.15	
			3,480.91
Furniture and Fixtures			783.85
Inventories—Publications			
655	Bibliographies	$ 0.00	
1,270	Indexes—10c	127.00	
8,311	Journals, 1918—10c	831.10	
8,092	" 1919—10c	809.20	
8,471	" 1920—10c	847.10	
10,543	" 1921—10c	1,054.30	
351	Transactions, paper	877.50	
171	" cloth	513.00	
			5,059.20
Total Assets			$19,794.47

LIABILITIES AND SURPLUS

Divisions, percentage of Dues paid in advance	$ 87.21
Dues paid in advance	1,084.59
Journals paid in advance	479.39
Surplus	18,143.28
Total Liabilities	$19,794.47

REPORT OF SPECIAL COMMITTEE TO STUDY QUESTION OF EMPLOYING FULL TIME SECRETARY

January 26, 1922.

To the President and Board of Trustees,
American Ceramic Society.

Gentlemen:

Your committee appointed for the purpose of investigating the feasibility of creating the office of a permanent secretary begs leave to submit the following report:

1. **Necessity of a permanent secretarial office.** The committee has investigated the need of a permanent secretaryship quite thoroughly and has come to the conclusion that such a necessity does exist. This condition has been brought about principally through the creation of the Industrial Divisions, which cannot be activated and brought to their highest efficiency without constant encouragement, assistance, and advice. It is evident that it would be utterly impossble for a part-time officer to conduct this work on the scale required. If it were not for this type of activity the committee is frank to say that it would not favor the establshment of a permanent secretaryship. As long as we have the Industrial Divisions we must either maintain them properly or allow them to continue in an indifferent fashion, or discontinue them. It would seem to be well worth while to make a strong effort to bring the Division to the highest level of efficiency possible.

2. **Auxiliary activities.** If the Socety establshes the office of a permanent secretary it would seem desirable also to have him assist in the development of industrial research, as, for example, in the work proposed by the heavy clay products associations and the white ware division, thus linking up the manufacturing interests more strongly with the activities of the Society. While this aspect of our work is still in the experimental stage it would seem desirable not to neglect the opportunity. This is an additional reason for the appointment of a permanent secretarial officer, though not the primary one.

3. **Consolidation of secretarial work.** From the standpoint of economy it would seem desirable to merge the recording and organizing activities of the Society in one position as soon as possible, and there appears to be no inherent reason why this should not be done with the beginning of the next official year.

4. **Financial conditions.** If the new position of secretary is created, the financial burden of the Society will be increased by a sub-

stantial amount. It is evident that the question of finances must receive careful attention. It would be a dangerous procedure to jeopardize the principal activity of the Society, that of publishing the Journal, by using the revenues which might be expended in enlarging the publication, a step urgently needed, or revenues produced by the Journal. Upon consideration of the income of the Society, it would seem feasible, however, to use a sum approximating $6,000.00 per year for the proposed new office, even though no allowance is made for revenue received from an increased membership, both individual and corporate, and not considering any increase in advertising revenue which should be considered as belonging solely to the Journal. It is but reasonable to expect that a secretary giving his whole time to the work should materially increase the membership of the Society, especially in connection with the heavy clay products industries and with respect to corporation members. For the period of perhaps a year such an increased expenditure would in all probability necessitate more rigid economy in the disbursements of the Society, but such a condition should become relieved after that time. It is obvious that a certain risk is involved in the step under consideration, but this is true of practically any enterprise, and in this case it is believed that the chances of success are exceedingly good. The financial prospects are intimately connected with the success of the Society as a whole. If we succeed in producing a Journal indispensable to each and every worker in the ceramic industry and succeed in connecting ourselves intimately with industrial activities, the financial question is a minor consideraton. In fact, we beleve that the income of the Society, under proper management, can be made to reach a very high figure, as compared with its present resources.

5. Sentiment of Society. The sentiment of the Society has been expressed quite clearly in numerous letters received by your committee. With but few exceptions, all were in favor of a permanent secretaryship. The committee has endeavored not to be influenced by the overwhelming desire for such an innovation and submits its own opinion based on the merits of the case, but the feeling of the membership cannot be disregarded when the proposition becomes concrete and ready for definite action.

6. Selection of a permanent secretary. It is quite obvious that the ability and personality of the permanent secretary selected must be carefully considered, since they mean success or failure of the enterprise. Two alternatives present themselves. Either a man of known ability and forceful personality is selected for the place, or a younger, less established man gradually trained for the position. This committee feels that the former procedure is much to be preferred,

as it avoids the loss of valuable time and perhaps the loss of precious opportunities.

7. **Duties of the proposed permanent Secretary.** It would seem that the duties of the proposed new position might be defined as follows:

a. The title of the new position up to the end of the present fiscal year should be: Organizing Secretary. With the beginning of the next fiscal year the incumbent should assume the title of General Secretary, with the combined functions of the present Secretary and those added under the head of the new duties.

b. The Organizing Secretary should conduct his work under the direction and supervision of the President and Board of Trustees and should be responsible to them. All proposed activities not previously defined or authorized should be subject to the approval of the Board of Trustees.

c. The Organizing Secretary should be Recording Secretary, ex officio, of all the Divisions of the Society and should be a member of the Committees on Membership, Papers and Programs, Research and Development, and Co-operation.

d. It should be the duty of the Organizing Secretary to assist the officers of the divisions in planning the work and executing the tasks undertaken. He should report to the Board of Trustees upon the status of the divisions at the expiration of every quarter. He should be charged with the duty of supporting and supplementing the work of the Committee on Membership and may be authorized by the Board of Trustees to undertake and prosecute such additional measures which promise to increase the membership of the Society, both individual and corporate.

e. It should be the duty of the Organizing Secretary to assist the Committee on Papers and Program in securing contributions of merit and in every way possible to aid in improving the programs of the meetings and bringing before the membership topics of vital and timely interest.

f. It should be the duty of the Organizing Secretary to work towards the establishment of co-operative researches, conducted under the auspices of the Divisions of the Society, and supported by Associations or groups of manufacturers, or single corporations. He should be charged with the duty of preparing research agreements, subject to the approval of the Board of Trustees. All disbursements made from funds made available to the Society for research purposes should be made by the Treasurer. It should be the duty of the Organizing Secretary to aid the Division Officers in formulating research programs

and to consult with the best experts available to the research problems. It should be his duty likewise to supervise the prosecution, reporting, and publication of such researches, unless other supervision is provided for by the Division of the Society, and to report to the Board of Trustees upon the progress of such work monthly.

g. It should be the duty of the Organizing Secretary to maintain frendly relations with the Associations of manufacturers and similar organizations, to address them on the subject of the work of the Society and related topics and to secure their co-operation in our several fields of endeavor.

h. This officer should be charged also with the duty of assisting in the preparation for meetings of the Society, the securing of suitable quarters and necessary equipment.

i. It should be the duty of the Organizing Secretary to undertake such duties as may be assigned to him by the President and the Board of Trustees. He should be required to submit to the Board of Trustees a monthly report showing all the various activities in which he has been engaged and the results obtained.

8. **Remuneration.** The salary of the Organizing Secretary should be at the rate of four thousand dollars ($4,000.00) per annum for the remaining part of this fiscal year and an allowance should be made of not more than two thousand dollars ($2,000.00) per annum for clerical assistance and travel. Beginning with the next fiscal year, with the change in position, the salary should be increased to five thousand dollars per year and the same allowance of two thousand dollars per year for additional clerical assistance and travel should be made. All expenses for assistance, travel, etc., should be properly accounted for by vouchers and approved for payment by the President

9. **Term of office.** A suitable contract should be prepared between the Board of Trustees and the person selected for the position of Organizing Secretary to cover the term of office of two years.

10. **Location of office.** The office of the Organiznig Secretary should be at the headquarters of the present Secretary, at Alfred, N. Y., if such an arrangement is feasible, until the end of the present fiscal year, when the location of a permanent office might be determined by the Board of Trustees.

11. **Recommendations.** Your committee begs to submit the following recommendations:

First. It is recommended that the position of an Organizing Secretary be created, with a salary of four thousand dollars ($4,000.00) per annum and with an allowance of not more than two thousand

dollars ($2,000.00) per year for clerical assistance and travel. This office to be in effect from the time fixed by the Board of Trustees to the end of the present fiscal year, when it could be merged with that of the General Secretary. With this consolidation it is recommended that the salary be increased to five thousand dollars per annum and the same allowance of two thousand dollars be made for clerical assistance and travel.

Second. It is recommended that the duties of the office be defined as outlined under section 7, to which are to be added those of the General Secretary at the beginning of the fiscal year of 1922. It is also recommended that the term of the office shall be fixed at two years, to be renewed at the option of the Board of Trustees. It would seem desirable to locate the office of the Organizing Secretary at the present headquarters of the Society until the end of the fiscal year of 1921, when it might be transferred to a suitable place designated by the Board of Trustees.

Third. In canvassing the men available for the position in question, we have come to the conclusion that Mr. R. C. Purdy possesses the necessary qualifications of ability, leadership, zeal, and energy to the fullest extent and we beg leave to submit his name for consideration.

(Signed)

A. V. BLEININGER,

EMERSON P. POSTE,

Committee.

Newell, W. Va., May 23, 1921.

REPORT OF EXECUTIVE CONFERENCE
Held Hotel Commodore, New York City
September 15 and 17, 1921

CO-ORDINATING SERVICE COUNCIL

Moved by Barringer, seconded by Beecher, that the definition of the objects of the Society are satisfactorily set forth in the present constitution. Motion carried.

Moved by Barringer, seconded by Riddle, that the present Committee on Co-operation, and Research and Development be merged into a single Committee on Co-operation and Research. Motion lost.

Moved by J. B. Shaw and seconded by Chester Jones, that this conference recommend to the proper authorities the adoption of this outline as amended (outline as amended is attached hereto). Motion carried.

Note—In accordance with this motion, Secretary Binns prepared written proposals for amendment to Constitution and By-laws; read them at the regularly called meeting of the Society, Friday afternoon, September 16, and transmitted them to Committee on Rules for action.

In the discussion there was a recognition of two distinct groups of standing committees (1) Internal Organization, (2) Service. The Committees on Rules, Membership, Program and Publication, constitute the first group, while the Research, Standards and Co-operation constitute the second group. The Board of Trustees is the direct co-ordinating agency for the first group, but because of the peculiar interests involved, both within Society and in co-operation with other organizations, it is well that the constitution provide a special organization, the personnel of which (appointed by the Board) has more direct responsibilities in the work of the Service Committees.

Co-ordination in the service work is thus more easily maintainable, and a readily recognized agency for co-operation with other organization is established.

It should be noted that the appointees to these service committees is largely by the Divisions, thus cementing the whole organization into a unit in these Service projects, the scheme as a whole simplifying, unifying and vitalizing the service agencies already provided for by the Constitution of the Scoiety and by the Rules of the Divisions.

MEMBERSHIP

Honorary. Without a motion consensus of opinion was obtained that the Membership Committee should formulate a proposal of procedure in securing nomination to Honorary Membership in the Society

of persons who had contributed largely to the promotion of ceramic arts and sciences by invention or discoveries.

Active. Moved by Bowman, seconded by Stone, that it is the sense of this conference that the Board of Trustees should scrutinize more closely the status of those to be elevated to active membership. Motion carried.

Perpetual. Moved by Riddle, seconded by J. B. Shaw, that the Membership Committee consider advisability of having this class of members, what the fee shall be, how earnings from the invested fee shall be used during life of member and after his decease, it being understood that the fee paid shall be set aside as a permanent fund, the interest earnings alone used. Motion carried.

In further consideration of this a consensus was had that (1) Personal Perpetual Membership fee should be $200.00, (2) the interest earnings be used to meet current expenses during life of the member and that on death of the member the principle be transferred to permanent research Endowment Fund, the interest from which should be used in support of research, (3) Corporation Perpetual Membership fee should be $500.00, the interest earnings on which should be used to meet current expenses of the Society.

LOCAL SECTIONS

Moved by Riddle, and seconded by Stone, that the whole question of re-districting, local meetings, etc., be referred to Committee on Sections and Divisions and Committee on Membership for formulation of recommendations. Motion carried.

CERAMIC TRADE SCHOOLS

Moved by J. B. Shaw, seconded by Stone, that this conference recommend to the Board of Trustees that they consider seriously the advisability of encouraging the establishing of Trade Schools in ceramics and the introduction of ceramic manual training courses in High Schools and laboratories. Motion carried.

COMMITTEE ON CERAMIC EDUCATION

Moved by Stone, seconded by Hottinger, that it be recommended to the Board of Trustees, that they consider establishing a committee on Ceramic Education.

DIVISIONS

The Enameling, Glass, Terra-Cotta, Refractories and Art Division reported in detail the manner in which they are working. Plans for the future were described. The Heavy Clay Products Division reported the initial step taken toward organization.

The White Wares Division reported that the most important question before it was whether it was practical to have the General Ware, Porcelain, Wall and Floor Tile, Sanitary and Insulator groups in one Division.

Letters were read from pottery manufacturers advising a separate Division for potters.

The officers and committeemen of the White Wares Division as now constituted, are studying this question, and will formulate recommendations to the Board of Trustees.

Shall Divisions Hold Mid-Year Meetings. The discussion brought out objections to too many meetings other than the regular meetings of the Society. Each Division will have its own peculiar needs in this respect. Plant inspection tours once a year were favored.

Promotion of Research Through the Divisions. L. I. Shaw, Chairman of Committee on Research and Development, stated that this committee will ask the Division to outline their research problems and will work with them in finding ways and means for carrying out their plans. Research facilities will be known and co-ordination and co-operation obtained wherever possible.

Issuance of Division Bulletins. After considerable discussion, in which the whole question of desirabilty of issuing to all members of the Society and Press "industrial journal copy" in some form, it was moved by L. I. Shaw, seconded by Stone, that this conference recommend to the Board of Trustees that the matter of issuance of a bi-weekly bulletin from the Secretary's office for the whole Society be taken under consideration to determine if such a bulletin can be issued without great financial burden on the Society, and that this conference go on record as believing that the issuance of such a bulletin is very desirable. Motion carried.

CHEMICAL EXPOSITION BOOTH AND MEETING

Comments were in favor of continuing both.

Moved by R. Montgomery, and seconded by Treischel, that it is the opinion of this conference that an exhibit in connection with the booth be seriously considered. Motion carried.

ENDOWMENT FUNDS

This was discussed but no action taken. The consensus of opinion was that all monies received for or diverted to a perpetual Research Fund should be invested by the Board of Trustees, and the earnings from the investments be used in manner nominated to the Board by the Co-ordinating Service Council.

EXCURSION TO EUROPE

Moved by Minton, seconded by Bowman, that the Secretary of the Society negotiate, through the Committee of the Glass Division, necessary arrangements for an excursion to Europe that will include all ceramic industrial groups. **Motion carried.**

ANNUAL MEETING

Consensus of opinion was for three-day convention, as now; publication of Committee and Board reports prior to convention to save time in first business session; provide ample room for Division meetings; use bulletin board in each Division meeting room announcing papers being read before other Divisions; have all papers of general interest on general program; have authors indicate whether paper is of general interest and, if so, abstract be submitted to Program Committee for decision whether or not it be read before general session; that abstracts or preprints be published prior to meeting; that the banquet and smokerette be continued as at present.

Employment of Stenographer. Moved by J. B. Shaw, seconded by Bowman, that this conference recommend to the Board the employment of a stenographer to take the discussion in the Division meetings. Motion carried.

Exhibits at Annual Convention. Moved by Staley, seconded by Stone, that this conference recommend that the Society arrange for Exhibits of Ceramic Products, machinery, etc., in connection with the annual convention, for which a charge will be made for space. Motion carried.

Special Session on Factory Problems and Equipment. It was the consensus of opinion that these should be continued, but that patentees and selling organizations should not be allowed to appear unless they have data showing actual performance of the article described; that the papers presented shall consist of engineering data rather than being an exposition of the apparatus or equipment.

Testing Laboratory Under Auspices of American Ceramic Society. Moved by Staley, seconded by J. B. Shaw, that this conference go on record as opposed to the Society maintaining a testing laboratory. Motion carried.

PUBLICITY

Moved by Staley, seconded by Stone, that this conference recommends to the Board that the General Secretary shall engage in publicity activities (1) by use of reprints and enclosures, (2) addresses at conventions, before clubs, schools, etc., (3) and by press and magazine articles. **Motion carried.**

CENTRALIZATION OF BUSINESS ACTIVITIES OF SOCIETY

After considerable discussion in which several speakers made it plain that there was no criticisms of the present editor, but rather praise for the excellent form and new features he has introduced, that there was no intention of recommending a change of the Journal Record of Ceramic Researches, but of adding Industrial Journal features and personal items in a detachable section or as separate bulletin as was proposed in a previous motion, agreement was informally had that when the finances would permit, an editor should be employed, but that for the present, in the interest of economy and effectiveness, it was:

Moved by Staley, seconded by Harvey, that this conference recommend to the Board of Trustees that the offices of Secretary and Editor be in same place, and that for the year 1922 it be combined in the same man, that of the General Secretary. Motion carried.

CO-ORDINATING SERVICE COUNCIL

General Secretary, ex-officio Chairman
Four members, appointed by Board of Trustees to serve as Chairman of Committees 1 to 4, inclusive

		Committee Members	Co-operation with other organizations
1. Committee on Research	Pure Science Applied and Industrial Science	3 members appointed by Board 1 member chosen by each Division	National Research Council (Div. Chemistry and Chemical Technology, Div. Research Extension, and Div. Engineering) Federal Bureaus Semi-Public, Commercial, and Industrial Laboratories Universities Trade and Technical Associations
2. Committee on Standards	(a) Definitions (b) Raw Materials Specifications (c) Standardization of Tests (d) Standardization of Products	(a) 3 members appointed by Board (b) 3 members appointed by Board (c) 1 member chosen by each Division (d) 1 member chosen by each Division	American Society for Testing Materials (Committees C-1 to C-11, inclusive, D-4, and D-9) Foreign Ceramic Societies Trade and Technical Associations Federal Bureaus American Engineering Standards Committee, etc.
3. Committee on Geological Surveys	Advisory on Tests and Interpretation of Data	4 members appointed by Board	National Research Council (Div. Geology and Geography) U. S. and State Geological Surveys
4. Committee on Data	(a) Symposiums (b) Monographs (c) Bibliographies (d) Statistics	1 member chosen by each Division	National Research Council Trade and Technical Associations Federal Bureaus Commercial Laboratories Universities

To the Board of Trustees,
American Ceramic Society.

REPORT FOR THE YEAR 1922
COMMITTEE ON STANDARDS

Your committee has not accomplished as much during the year as had been hoped. The reason is to be found in the unavoidable slowness attendant upon carrying on work of this character by mail. There has been very good co-operation among the members of the committee, and the care and energy they have shown is evidence enough of their interest in and enthusiasm for the work.

The new plan of organization for carrying on the Standardization work, whereby each Division has an opportunity to be represented, has not had a sufficient trial to allow of a conclusion as to its effectiveness. The principle underlying that plan of organization is fundamentally correct, but it is apparent that a better definition of the functions of the various sub-committees would be desirable. Some suggestions to this end follow:

1. "Tentative" ("Provisional" or "optional") tests, specifications or definitions need not be referred to the members of a Division for ballot before publication, nor for criticsm before publication except the Divisional Standardization Committee so chooses. To do this greatly encumbers the work by slowing it up and scattering the discussion. Moreover, the taking of a ballot, even though it be of a preliminary kind, clothes the test or specification with the same status or authority as a "Standard" by very reason of the fact that such ballot has been taken.

2. Whenever (after the "Tentative" test has been in print for the required time), the Divisional Standardization Committees decides to recommend any "Tentative" test or specification for adoption as "Standard," it should make that recommendation to the Committee on Standards. When they have likewise agreed, then the "Tentative" test or specification should be referred by the Division officers to a letter ballot by the members of the Division involved. Each Division should have within itself authority to make standards. The function of the Committee on Standards, as far as concerns the Divisions themselves, is to avoid the adoption within the Society of conflicting standards, and to be the medium through which they present their adopted standards to the Society for recognition as the Society's standards.

3. The bulk of the work of preparation of methods and specifications should be done by the Divisional Committees. Experience has shown that a very large amount of work is necessary to carefully review and carry on the discussions necessary for bringing the members of the General Committee into substantial agreement. This General Committee should obviously be as small as is consistent with giving adequate representation to each Division. This can be accomplshed in the plan of organization recently approved, whereby the Committee on Standards is made up of four sub-committees, if each of these sub-committees is made an entity as distinct as the Committee on Standards has itself been in the past.

It is very important that a well attended session of the Committee on Standards be held at each annual meeting, preferably on the day after the general sessions close, so that adequate time will be available for deliberation. A plan for the year's work carefully prepared in detail should be the result of these deliberations. Such a vast amount of work yet to be done and chance to do relatively so little in a single year, makes it imperative that an outline of work be made and that outline rigidly adhered to. The many different issues coming up durng the year make it easy to get side-tracked, with the result that in the end nothing definite and finished is accomplished.

During the year the Committee has carefully reviewed the six Standard Methods approved by the Society April 1, 1920. No amendments or corrections are recommended in them. The seven Tentative Methods have been amended in some important particulars and are again presented as Tentative.

The Standardization Committee of the Refractories Division submitted for approval by the Committee on Standards, the A. S. T. M. "Standard Method of Test for Refractory Materials under Load at High Temperatures." The Committee approves this method as Tentative and recommends its adoption as Standard.

"Tentative Methods for Testing Electrical Porcelains" were submitted by Committee D-9 of the American Society for Testing Materials under their Serial Designation D 116-21T. It was presented before that Society at its June, 1921, meeting.

The Committee on Standards approve these methods as Tentative but offer the following recommendations:

1. The machine for determining resistance to impact is not clearly defined. The velocity of fall of the hammer can vary appreciably with different degrees of accuracy in the machining of the vertical guides and the guide holes, also with varying degrees of accuracy in the hammer itself with respect to symmetry.

2. In the method of tensile strength, the rate of application of load should be defined. This is generally recognized as essential in the detrmination of tensile strength of other materials, and the same should apply to porcelain.

3. The hot and cold test described on Page 30, Article 22A, would be preferable if it were made at five minute rather than ten minute immersions in hot and cold water. Where 100 immersions are required an enormous amount of time is necessary if the ten minute interval is used, and practically the same degree of accuracy can be obtained with five minute immersions.

The Standardization Committee of the Refractories Division submitted for approval by the Committee on Standards, the A. S. T. M. "Standard Definitions for Clay Refractories" (A. S. T. M. Standards 1921, p. 649).

The Committee approves these as tentative, but does not wish to recommend their adoption as standard until the A. S. T. M. "Standard Test for Porosity and Permanent Volume Changes in Refractory Materials" (A. S. T. M. Standards 1921, p. 622), has had more detailed study. At present this standard test is not in as good agreement with our adopted methods as could be hoped.

In the pages which follow are given the Standard and Tentative methods and definitions as approved by the Society or Committee to date.

COMMITTEE ON STANDARDS,
M. F. Beecher, Chairman.

Committee on Standards

1919	1920	1921
M. F. Beecher, Chair.	M. F. Beecher, Chair.	M. F. Beecher, Chair.
M. C. Booze	C. W. Berry	M. C. Booze
J. B. Shaw	M. C. Booze	E. C. Hill
E. P. Poste	E. E. F. Creighton	F. H. Riddle
E. E. F. Creighton	R. R. Danielson	Hewitt Wilson
C. W. Berry	C. B. Harrop	A. Silverman
F. H. Riddle	E. C. Hill	F. J. Frost
R. M. Howe	R. M. Howe	J. S. McDowell
Hewitt Wilson	R. K. Hursh	
R. K. Hursh	F. H. Riddle	
F. A. Kirkpatrick	J. B. Shaw	
C. B. Harrop	Hewitt Wilson	
E. C. Hill	E. P. Poste	
I. A. Williams	I. A. Williams	
	O. J. Whitemore	

TABLE I

Amounts of Clay Required for the Several Tests

	No. of test pieces	Size	Approx wgt. of test pieces	Min. wgt. of clay that should be provided
Drying shrinkage	2	30x30x45mm.	130 gr.	300 gr.
Water of plasticity	3	30x30x45mm.	195 gr.	400 gr.
Shrinkage and pore water	—	—	—	—
Behavior in firing	10	30x30x45mm.	640 gr.	1200 gr.
Softening point	10	cones	7 gr.	100 gr.
True specific gravity	—	—	—	50 gr.
Ultimate chemical analysis	—	—	—	50 gr.
Fineness	—	—	—	600 gr.
Sag	10	12x25x230mm.	1210 gr.	2500 gr.
Slaking	2	2.5x2.5x2.5cm.	14 gr.	50 gr.
Transverse strength	10	17.5x2.5x2.5cm	940 gr.	2000 gr
Total				7250 gr. (16 lbs.)

TENTATIVE METHOD FOR SAMPLING CLAY DEPOSITS

(1) Preliminary Sampling

A face of the body of clay to be sampled shall be carefully stripped of loose or foreign materials, and a series of parallel trenches cut, each a straight line, so as to make as nearly as may be a vertical section entirely across the outcrop. In the case of stratified or bedded deposits which are inclined, the direction of these trenches shall be, preferably, across the dip, so that a proportionate amount of clay will be obtained from each individual layer. Each trench shall be about 12″ wide, and deep enough to produce at least 100 pounds of material. Where natural outcrops are not available for a sampling, preliminary trials may be made with a hand auger, and test pits dug to the necessary depth to expose a section (or face) of the clay.

As this may yield more material than is necessary for even a complete series of tests, the clay from the different trenches shall be reduced to lumps not exceeding 2″ in diameter, mixed together and reduced by quartering to about 100 pounds which is to be sent to the testing laboratory. The quartering shall be done on a heavy sail cloth at least 8′ square.

If the deposit shows distinct difference as regards structure, color or texture, each bed showing these individual differences shall be sampled separately, provided these beds are sufficiently thick to be mined by themselves or can be thrown out if undesirable.

Where the clay is stored in stock piles the sample may be taken from these PROVIDED THEY ARE REPRESENTATIVE. At least one-half of the sample shall be taken from the lower third of the pile.

In the case of those clays which are being purified a sample of both the crude material and the clay as prepared for the market shall be taken.

The samples collected as outlined above shall be placed in clean, tight-weave strong sacks and carefully labeled by means of two tags each bearing the proper identification marks. One folded tag shall be placed within the sack and the other securely attached to the outside.

(2) Extended Sampling

After a clay proves satisfactory in the preliminary testing, the surrounding tract must be surveyed and systematically sampled. A topographical survey of the tract shall be made. Holes shall be drilled or dug through the deposit not more than 100′ apart. A record shall be kept of the thickness of each stratum encountered. By plotting

these results to scale the shape, size and dip of the strata can be estimated.

A few larger holes shall be dug at the extremities of the property or at any points of doubtful value in order to get samples large enough for a complete series of tests. These shall be taken under the direction of "Preliminary Sampling."

TENTATIVE METHOD FOR SAMPLING CERAMIC MATERIALS AS DELIVERED

SHIPPED AND STORED IN AN UNGROUND CONDITION

"Unground condition" shall mean material as mined which has not been crushed, ground, or intentionally mixed.

(1) **Time of Sampling**—The material shall be sampled when it is being placed into or taken from railroad cars, ships, barges, wagons, casks, bags, etc. Samples can usually be taken advantageously as the material passes through the crusher. Samples collected from the surface of piles, bins, cars, etc., are generally unreliable. However if it is necessary to sample under such conditions, one-half of the sample shall be taken from the lower third and one-half from the upper two-thirds.

(2) **Collection of the Gross Sample**—To collect samples, a shovel or specially designed tool or mechanical means shall be used for taking equal portions or increments. The increments shall be regularly and systematically collected so that the entire quantity of material sampled will be represented proportionately in the gross sample, and with such frequency that the gross sample of the required amount shall be collected.

(3) **Size of the Standard Gross Sample**—The standard gross sample shall not be less than 1% of the total shipment.

SHIPPED AND STORED IN A CRUSHED OR PULVERIZED CONDITION

(4) **Time of Sampling**—If the material is shipped loose, the sampling shall be done during loading or unloading as described under 1.

If the material is in containers, all containers of each shipment shall be so marked, tagged or labeled that they can be distinguished from all other shipments, and that ready reference can be had to the shipper's name and the date of delivery.

(5) **Method of Collection of the Gross Sample**—If the material is loose the gross sample shall be taken as described under 2. If in containers, an opening shall be made in the sack or barrel and a

portion of the contents shall be withdrawn. This sample should not be taken from the top alone but should represent all portions of the contained material. This can be done with the aid of an open pipe, spoon shaped rod or other suitable apparatus. If there is any reason to doubt the uniformity of the shipment, it is best to test separately a larger sample from each container.

(6) Size of the Standard Gross Sample—The standard gross sample shall not be less than 0.2% of the total lot sampled.

TREATMENT OF THE GROSS SAMPLE

(7) Crushing of Gross Sample—After the gross sample has been collected in the case of unground material, it shall be systematically crushed, mixed and reduced in quantity by quartering to convenient size for testing. The largest sizes of pieces allowable with various weights of samples are shown in the following table.

100 pounds plus	2.0 inches
100 — 50 pounds	1.0 inches
50 — 25 pounds	0.25 inches
25 — 10 pounds	No. 4 sieve
10 — 5 pounds	No. 10 sieve
5 pounds	No. 20 sieve

Quartering: The sample crushed to the required size shall be thoroughly mixed by coning and reconing on a clean surface. The cone shall be flattened and then marked into quarters by two lines which intersect at right angles directly under a point corresponding to the apex of the original cone. The diagonally opposite quarters shall then be removed and the space that they occupied brushed clean. The material remaining shall be successively crushed, mixed, coned and quartered until two opposite corners shall equal the size necessary for testing.

The final portion shall be placed in a container suitable for storage or shipment and carefully marked.

References:

(1) Bulletin 116, U. S. Bureau of Mines.
"Methods of Sampling Delivered Coal" by G. S. Pope

(2) "Report of Sub-Committee on Field Sampling of Clays"
Committee on Ceramic Chemistry of National Research Council

(3) Bulletin No. 43 Iowa Engineering Experiment Station
"Practical Handling of Iowa Clays" by Staley and Beecher.

STANDARD METHOD FOR DRYING SHRINKAGE

(Adopted April 1, 1920)

(1) Size and Shape of Test Pieces

The test pieces shall be made approximately 30x30x45mm (1⅛x 1⅛x1⅞ inches). It is apparent that the dry dimensions will vary with different clays.

(2) Preparation of the Clay

The clay shall be thoroughly dried at a temperature above 64°C but under 76° C and crushed to pass a standard No. 20 sieve. (Tentative Standard Series for Testing Sieves.) It shall then be made up with water to a soft plastic consistency and thoroughly wedged and kneaded by hand.[1]

(3) Making Test Pieces

The test pieces shall be made in a suitable metal mold[2] measuring approximately 30x30mm (1⅛x1⅛ inches) by any desired length. After making, the pieces shall be cut into 45mm (1⅞ inch) lengths. The mold shall be thinly and evenly oiled with kerosene or a light machine oil only as frequently as is necessary to keep the clay from sticking. The test piece shall be formed by taking in the hand a lump of clay, somewhat larger than required to fill the mold, and kneading it into a roll approximately the length of the mold. It shall then be placed in the mold and forced into the corners by blows with the cheek of the fist. The excess shall then be struck off with a wire and the piece slicked with a spatula and appropriately marked or numbered for identification. Care should be taken by the operator to keep his hands free from oil. The test piece shall be removed from the mold immediately and transferred to a smooth, straight pallet, care being taken not to distort it.

If preferred the test piece may be made in a piston plunger press fitted with a die 30mm (1⅛ inches) square. In either event the corners of the test piece shall be slightly rounded.

(4) Plastic Volume

The plastic volume shall be determined immediately in a volumeter of the Seger type.[3] Kerosene with a specific gravity of about 0.8 shall be used as the measuring fluid. The volume shall be read to the nearest 0.1 cc.

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[1] This consistency will permit of the careful handling of the piece immediately after forming.

[2] See appendix for detail of suitable molds.

[3] For details of several instruments, see appendix.

(5) Drying

After the plastic volume is determined the surfaces of the test pieces shall be dried lightly with a soft cloth to remove the film of kerosene, and allowed to dry at room temperature until air dry. They shall then be dried at a temperature between 64°C and 76°C for at least five hours and finally at 110°C to approximately constant weight. They shall not be allowed to cool to room temperature between these two drying operations unless they be placed in a desiccator. After the final drying treatment they shall be placed in a desiccator to cool and remain there until the test is continued.

(6) Dry Volume

The dry test pieces shall then be allowed to soak in kerosene of the same specific gravity as that used in the volumeter for at least 12 hours, after which the volume shall be determined in the same manner as specified for the plastic volume in article 4. The volume shrinkage shall be calculated by the following formula:

$$b = \frac{Vp - Vd}{Vd} \times 100$$

in which b = percent volume shrinkage
Vp = the plastic volume
Vd = the dry volume

(7) Linear Shrinkage

This value shall be calculated from the percent volume shrinkage by the formula

$$a = \left[1 - \sqrt[3]{1 - \frac{b}{100}}\right] \times 100$$

in which a = percent linear shrinkage.

(8) Report

In reporting drying shrinkage, the following information shall be given and these values shall be the means of results obtained on two test pieces:

(a) Volume shrinkage in percentage of the dry volume.
(b) Linear shrinkage in percentage of the dry length.

STANDARD METHOD FOR WATER OF PLASTICITY

Adopted April 1, 1920

(1) Test Pieces

The test pieces shall be of the same size and shape and made in the same manner as defined in the Method for Drying Shrinkage, articles 1, 2, and 3.

(2) Plastic Weight

The edges and corners of three test pieces shall be rubbed lightly with the finger to prevent loss in handling. They shall then be weighed on a balance to an accuracy of 0.1 gram.

(3) Drying

After the plastic weight is obtained the test pieces shall be allowed to dry at room temperature until air dry. They shall then be dried at between 64°C and 76°C for at least five hours and finally at 110°C until approximately constant in weight.

(4) Dry Weight

The dried test pieces shall be cooled to room temperature in a desiccator and then weighed with the same accuracy as before (article 2).

(5) Calculation

The water of plasticity shall be calculated as a percentage of the weight of the dry clay bar, by the following formula:

$$T = \frac{Wp - Wd}{Wd} \times 100$$

in which T = percent water of plasticity
Wp = weight of the plastic test piece
Wd = weight of the dry test piece

(6) Report

The average of the three values obtained shall be reported as the percent water of plasticity.

STANDARD METHOD FOR SHRINKAGE AND PORE WATER

Adopted April 1, 1920

Preface

"Shrinkage Water" is defined as that portion of the water of plasticity which is driven off up to the point where shrinkage ceases. "Pore Water" is defined as that portion of the water of plasticity which is driven off from the point where shrinkage ceases until the clay piece has reached approximately constant weight at 110°C. Thus shrinkage water plus pore water equals the water of plasticity.

Method

(1) Data

The data necessary for the calculations here involved are the plastic volume and the dry volume, as determined in the Method for Drying Shrinkage, and the dry weight and water of plasticity as determined in the Method for Water of Plasticity.

(2) Shrinkage Water

The following formula shall be used:

$$t_1 = \frac{Vp - Vd}{Wd} \times 100$$

in which t_1 = the percent shrinkage water
Vp = the plastic volume in cubic centimeters
Vd = the dry volume in cubic centimeters
Wd = the dry weight in grams

(3) Pore Water

The following formula shall be used:

$$t_2 = T - t_1$$

in which t_2 = the percent pore water
T = the percent water of plasticity

STANDARD METHOD FOR BEHAVIOR IN FIRING

(Adopted April 1, 1920)

Preface

Data Required

In order to determine the behavior of a clay in firing, the following data must be obtained:

a. Progressive change in porosity
b. Progressive change in volume

Additional Useful Data

Knowledge of the following properties will always be useful checking, in a measure, the accuracy of the above determinations: changes in

c. color
d. hardness
e. absorption
f. mechanical strength
g. apparent specific gravity

Method

(1) Test Pieces

The clay shall be prepared and the test pieces formed, as defined in the Method for Drying Shrinkage, articles 1, 2, and 3. They shall then be dried and the dry volume determined as defined in articles 5 and 6 of the same method.

(2) Firing

The test pieces shall be placed in a refractory muffle or sagger as thin-walled as possible, which is set in the test kiln. The test pieces shall not be stacked together too compactly. The test kiln shall be of such size that the effective space available is not less than 1½ cubic feet. The heating may be accomplished by any convenient means but the temperature distribution should be thoroughly explored during the first few firings. A set of pyrometric cones of the Seger formulae as made by Professor Edward Orton, Jr., shall be placed as closely to the stacked up test pieces as possible; [1] but temperature control by means of a platinum-platinum-rhodium thermocouple is

[1] A suitable arrangement of cones and test pieces is illustrated in the appendix.

required also. The temperature therefore shall be reported in terms of cones and the pyrometric readings, in which correction has been made for the cold junction temperature.

The range of cones used shall cover the firing range of the clay, which must be judged by the operator. Generally, the cones to be placed in the kiln are 014 to 3 for impure, common brick clays; 012½ to 5 for shales and the better types of ferruginous clay; and 02 to 15 for clays of the fire clay type. Oxidizing conditions must be maintained during firing.

The heating shall preferably be at the rate of 45°C per hour from the start of the firing until a heat treatment is reached, corresponding to the softening point of the third consecutive cone below that at which the first trial is to be drawn; and 20°C per hour from that point until the end of the firing. In no case shall the rate of heating be greater than 60°C per hour nor less than 30°C per hour for the first period, or greater than 25°C per hour nor less than 15°C per hour for the last period.

(3) Drawing the Test Pieces

According to the nature of the clay, test pieces are first drawn at cone 010 for impure, common brick clays; cone 08 for shales and the better grades of ferruginous clay; cone 2 for clays of the fire clay type. A test piece is then drawn from the kiln at each interval of two cones, and immediately before drawing the temperature indicated by the pyrometer shall be recorded. The removal of the test piece from the kiln shall be done as quickly as possible to avoid cooling down the kiln too much. It will be necessary as a rule to increase the rate of application of heat a little after each draw.

Upon removal from the test kiln the test pieces shall be (a) immediately covered with hot sand or (b) placed in a small supplementary furnace kept at a dark red heat and large enough to hold all of the test pieces to be drawn. Upon completion of the firing the auxiliary furnace shall be allowed to cool at the natural rate. (While it is recognized that furnace control by means of a thermocouple is more definite and accurate than with prometric cones, especially for testing purposes, trials have demonstrated that the use of cones minimizes the variations between one firing and another due to slight differences in rate and uniformity of heating.)

(4) Weighing

When cool enough to handle, the test pieces shall be placed in a desicator containing concentrated sulphuric acid until they have cooled to room temperature. They shall then be carefully inspected and any adhering particles of sand or other material, picked up during firing, carefully removed. They shall then be weighed on a balance to an accuracy of 0.1 gram.

(5) Saturation

The weighed test pieces shall be placed in distilled water in a suitable vessel and boiled for two hours, then allowed to cool to room temperature, while still immersed in water. During boiling, the test pieces shall not be in contact with the heated bottom of the container.

(6) Saturated Weight

When cooled to as near 20°C as possible in the room atmosphere, each test piece shall be dried lightly with a damp towel to remove the excess water and weighed in air to an accuracy of 0.1 gram. They shall then be again immersed in distilled water until they are required for the volume determination.

(7) Fired Volume

The fired volume shall be determined in a volumeter of the Seger type[2] using distilled water for the measuring fluid. The test pieces shall be introduced into, and removed from the volumeter in substantially the same manner so as not to appreciably change the volume of water in the instrument.

(8) Apparent Porosity[3]

The apparent porosity shall be calculated by means of the following formula:

$$P = \frac{Sf - Wf}{Vf} \times 100$$

in which P = the percent apparent porosity

Sf = weight of the saturated fired test piece in grams

Wf = weight of the fired test piece in grams

Vf = volume of the fired test piece in cubic centimeters

[2] For details of several instruments, see appendix.
[3] For refined method for special bodies, see appendix.

(9) Volume Change

The volume change shall be determined by the relation.

$$b_1 = \frac{Vd - Vf}{Vd} \times 100$$

in which b_1 = percent volume change

Vd = volume of the dry test piece in cubic centimeters

(10) Apparent Specific Gravity[4]

The apparent specific gravity shall be determined by the formula

$$G = \frac{Wf}{Vf - (Sf - Wf)}$$

in which G = the apparent specific gravity

(11) Bulk Specific Gravity

The bulk specific gravity shall be calculated by the formula

$$Gb = \frac{Wf}{Vf}$$

in which Gb = the bulk specific gravity

(12) Plotting Results

When the results are plotted in graphical form (and this is advisable) heat treatment is preferably expressed in cone numbers. Under each cone number at which a trial is drawn, the reading of the temperature measuring instrument in degrees Centigrade shall be given. Equal distances on the abscissa and ordinate shall represent 2 cones and 5% porosity respectively. The same value of coordinates shall be used in expressing volume changes.

(13) Color Changes

Color changes should be described in the usual conventional manner.

(14) Hardness

Changes in the hardness are determined by cutting the trials with a knife blade or noting the relative hardness of the trials as compared with steel.

(15) Absorption

Absorption shall be reported as a percentage of the weight of the dry sample, and shall be obtained by dividing the weight of water absorbed, in grams, by the weight of the dry test piece, in grams.

[4] For distinction between true, apparent, and bulk specific gravity, see appendix.

STANDARD METHOD FOR SOFTENING POINT

(Adopted April 1, 1920)

The method is applicable as well to fire brick and refractory materials in general, as to clays.

(1) Preparation of the Sample

The sample shall be obtained with the same care and precision as for chemical analysis. If the material is hard enough to require it, it may be reduced in a hardened tool-steel mortar using a pestle of the same sort, to a fineness allowing of finish grinding in an agate mortar. After grinding in the steel mortar, in the case of fired samples, any iron introduced by the mortar must be removed with a magnet before grinding is finished.

The sample shall be finally ground to pass a No. 60 sieve (Tentative Standard Scale for Testing Sieves), care being taken to prevent excessive reduction of the fines, by frequent removal through the sieve.

(2) Test Pieces

The test pieces shall be the size and shape of pyrometric cones; tetrahedra 7mm along the edge of the base and 30mm high. They shall be molded in steel molds, preferably allowing a somewhat greater height so that they may be cut to the required dimension when dry. If the sample is of a fired material or one deficient in plasticity, an organic binder such as gum or glue may be added to facilitate molding. If desired, the test pieces may be biscuited at a temperature safely below vitrification, before mounting.

(3) Mounting

The test pieces shall be mounted on a plaque of refractory material of such a composition as will not affect their fusibility; for example, equal parts of a highly refractory clay and fused alumina passing a No. 100 sieve. The base of the test pieces and pyrometric cones shall be imbedded not more than 2mm in the plaque, and their troweled faces (the numbered face of the pyrometric cones) shall make an angle of 75° with the plaque.

The test pieces shall be arranged on the plaque, alternating with pyrometric cones of successive numbers.

The pyrometric cones here specified shall be of the Seger formulae as manufactured by Professor Edward Orton, Jr.

The plaque may be of any convenient size and shape and may be biscuited, after mounting cones and test pieces, at a temperature safely below the vitrification of the test pieces, if desired.

(4) Furnace

The furnace shall preferably be one which will give a neutral or oxidizing atmosphere, and the heating chamber shall be frequently explored to discover any unequal heating. In a gas or oil furnace, care shall be taken that the flame does not impinge directly upon the test pieces, cones, or plaque. Excessive reducing conditions should be avoided.

(5) Rate of Heating

The rate of heating shall not exceed 50°C per five minutes, after 800°C has been reached.

(6) Softening Point

The softening point of a cone or test piece is indicated by its tip bending over and touching the plaque. The softening point of the test piece shall be reported in terms of the serial number of the pyrometric cone which corresponds in time of softening with the test piece. If the test piece softens later than one cone and earlier than the next, the softening point shall be reported thus; for example, cone 31-32.

If the test piece starts bending at an early cone but is not down until two or more successive higher cones have softened, the fact shall be reported; also any bloating, squatting, or unequal fusion of constituent particles.

Two or more tests at the proper temperature shall be made.

STANDARD METHOD FOR TRUE SPECIFIC GRAVITY

(Adopted April 1, 1920)

(1) Sample

For raw ceramic materials the sample shall be taken with the same care and precision as for chemical analysis. For fired materials the sample shall consist of at least two portions of the test piece or ware, from different positions, and the ratio of original surface to volume shall not be greater than in the whole piece.

The sample shall be crushed between hardened steel surfaces, when crushing is necessary, and then ground in an agate mortar, to pass a No. 100 sieve (Tentative Standard Scale for Testing Sieves). In fired samples or those not likely to contain magnetic material as an original constituent, any magnetic material present after crushing shall be removed with a magnet. About 10 grams shall be prepared in this manner, dried to constant weight at 110°C, and placed in a glass-stoppered weighing bottle.

(2) The Picnometer

The picnometer shall be of good quality and workmanship with the mouth ground flat so that there shall be no rounded recess between stopper and bottle when the stopper is in place. The stopper with a capillary tube shall be used.

(3) Weighing

All weighings shall be made on an accurate chemical balance to the fourth decimal place in grams, with material, and in an atmosphere at a temperature of 20°C+ or —1°C. The weight of the bottle and stopper dried at 110°C shall be recorded as "p" and the weight of the bottle filled with distilled water with the stopper in place as w_1.

(4) Introducing the Sample

About two grams of the sample shall be placed in the picnometer (which has been dried at 110°C) and weighed with the stopper, the weight being recorded as "w." The bottle shall then be filled to approximately one-third its capacity with distilled water, the stopper put in place with a piece of paper between stopper and bottle to prevent sticking, and boiled with care for 15 minutes. The bottle shall then be filled with distilled water to the base of the neck and allowed to cool to 20°C+ or —1°C. When cool and the sample settled, the filling shall be completed and the bottle wiped dry with a soft cloth.

(5) Final Weighing

The Picnometer shall then be weighed and the weight recorded as "w_2."

(6) Calculation

The true specific gravity shall be obtained by the formula:

$$Gt = \frac{w - p}{(w\text{-}p) - (w_2\text{-}w_1)}$$

in which Gt = the true specific gravity

w = weight of the stoppered picnometer and sample

p = weight of the stoppered picnometer

w_1 = weight of the stoppered picnometer filled with water

w_2 = weight of the stoppered picnometer, sample and water

(7) Checks

Two determinations shall be made and reported and they shall check to within 0.005.

TENTATIVE METHODS FOR ULTIMATE CHEMICAL ANALYSIS

(These are in agreement with that portion of the "Standard Methods of Ultimate Chemical Analysis of Refractory Materials, including Chrome Ores and Chrome Brick," A. S. T. M. serial designations C18-21, referring to General Refractories).

Preface

It will be understood that the making of a complete silicate analysis is a difficult procedure requiring a wide knowledge of the chemistry involved in the operations, and a thorough training in carrying out the work. A skilled analyst of good training is therefore required to do the work. The descriptions here given cover the vital points of procedure, but frequent reference in regard to the details of the various manipulations must be made to Bulletin No. 700, United States Geological Survey on "Analysis of Silicate and Carbonate Rocks," by W. F. Hillebrand; also, to "Treatise on the Ceramic Industries" Vol. 1 (1913) by J. W. Mellor; and to similar publications.

I. GENERAL CONSIDERATIONS

(1) Grinding of Sample

The sample shall be crushed in a hardened tool-steel mortar, using a pestle of the same sort. Fine grinding shall be done in an agate mortar, either by hand, or by a mechanical sample grinder of the McKenna, Carling or similar type, so constructed as to prevent the introduction of impurity.

(2) Statement of Analysis

Moisture shall be determined in the sample in its ordinary air-dried condition, and all other percentage compositons shall be calculated to a moisture-free basis. Whenever a sample is weighed out for any determination, a moisture determination shall also be made. If preferred, the sample may be dried in a weighing bottle, from which the required samples shall be weighed out.

(3) Checking Results

In all cases, check determinations shall be made, and the results shall be redetermined if satisfactory checks are not obtained. It shall be considered satisfactory if the differences between check determinations do not exceed the following limits:

For silica or other constituent amounting to 30 per cent or over..... 0.3 per cent

For alumina or other constituent amounting to 10-30 per cent..... 0.2 per cent

For any other constituent amounting to under 10 per cent..... 0.1 per cent

These figures are stated in terms of the whole sample as 100 per cent.

II. SOLUTIONS REQUIRED

(4) Concentrated Acids

The acids referred to as concentrated shall be of approximately the following specific gravities:

Hydrochloric acid (HCl)..... 1.20
Sulphuric acid (H_2SO_4)..... 1.84
Nitric acid (HNO_3)..... 1.42

(5) Ammonium Carbonate

Dissolve 1.5g. of ammonium carbonate in 50cc. of cold water.

(6) Ammonium Chloride

Dissolve 107g. of NH_4Cl in 1000cc. of warm water.

(7) Ammonium Nitrate

Neutralize 20cc. of concentrated HNO_3 with NH_4OH and dilute to 1000cc. Test with litmus; the solution shall not be acid.

(8) Ammonium Oxalate

Dissolve 1g. of ammonium oxalate in 50cc. of water, heating gently.

(9) Standard Titania Solution

The strength of the final standard titania solution shall be 1cc. = 0.0001g. TiO_2. To prepare the solution weigh out in a platinum crucible an amount of potassium titanium fluoride (K_2TiF_6) sufficient to make from ½ to 1 liter of "stock solution" in which 1cc.=0.001g. TiO_2. Evaporate several times with H_2SO_4 without taking to dryness, thus driving out all fluorine. Take up the residue with water containing enough H_2SO_4 to make at least 5% of the solution, when finally diluted to the standard solution strength. To standardize the stock solution take out two 50cc. portions, dilute, boil and precipitate with ammonia. Filter, wash with hot water until free from alkali, ignite, blast and weigh. The duplicate should check very closely.

From the weight of titania thus determined calculate the strength of the stock solution. The standard solution to be used is obtained from the stock solution, by diluting until 1cc. = 0.0001g. (TiO_2).

(10) Standard Potassium Permanganate Solution

Dissolve about 0.4g. (a little less) of $KMnO_4$ in one liter of water and check against an iron solution of known purity and strength.[1] Dilute the solution until 1cc. = 0.001g. Fe_2O_3.

III. METHODS

(11) Moisture

To determine moisture, heat approximately 1g. of the sample at a temperature not under 105 nor over 110°C. to constant weight.

(12) Ignition Loss

To determine loss on ignition, heat about 1g. of the sample over a blast lamp or in an electric furnace at 900 to 1000°C, to constant weight. Ignition loss may be determined in the sample from which the moisture has been removed. The percentage of ignition loss is calculated to a moisture-free basis.

(13) Silica

To determine silica, weigh out approximately 0.5g. of the sample and mix with 5g. of Na_2CO_3. Put a little Na_2CO_3 in the bottom of the crucible before introducing the mixture, and then cover the mixture with a little more Na_2CO_3. Fuse over a Meker burner or blast lamp until complete solution is obtained. Cool the fusion and as it solidifies, rotate the crucible to spread the mass up the side walls. Dissolve the fusion in about 100cc. of water in a platinum or porcelain evaporating dish. Add about 20cc. of concentrated HCl, introducing it slowly by means of a pipette, keeping the dish covered with a watch glass. Evaporate to dryness and heat until the fumes of HCl are gone. Add about 5cc. of concentrated HCl and 30 to 40cc. of water. Warm on a water bath for 10 to 15 minutes and break up the lumps. Decant the clear liquid onto a filter paper and collect the filtrate in a 400cc. beaker. Add more HCl and water to the evaporating dish, warm again and decant, repeat this a third time.

Finally transfer the contents of the dish to the filter paper. Wash with cold water until silver nitrate shows no chlorides to be

[1] The ordinary chemical iron wire is not sufficiently pure for this use. If preferred the solution may be standardized against sodium oxalate, a pure form of which is prepared especially for such work by the U. S. Bureau of Standards, Washington, D. C.

left. Transfer the filtrate to the original evaporating dish, evaporate again to dryness, take up with a little HCl and water, transfer to a new filter paper and wash as before. Transfer both silica precipitates to a platinum crucible. Ignite carefully over a Bunsen flame until the filter paper is burned off, then blast for about 30 minutes; cool and weigh. Repeat blasting for five minutes, weigh again and repeat until constant weight is obtained.

To the residue in the crucible add about 5cc. of water and 5 drops of H_2SO_4. Add HF drop by drop at first, and then slowly until the crucible is almost one-half filled. Warm on a hot plate until almost dry, add 2 or 3cc. more of HF and evaporate to dryness. Heat the crucible to bright redness and then blast for 5 minutes. Cool and weigh and repeat blasting to constant weight. The loss in weight from the original silica residue represents the actual silica content (SO_2), except for that part of silica which is later recovered from alumina, etc. The residue from the HF evaporation is left in the crucible and the total precipitate of alumina, etc., is added to this same crucible in which it is ignited and weighed.

(14) Alumina

Regarding the determination of alumina, reference should be made to Scientific Paper No. 286 of the U. S. Bureau of Standards by Dr. Blum on "Determination of Alumina as Oxide."

To determine alumina, to the filtrate from the silica determination, add about 10cc. of NH_4Cl solution and heat to boiling. Then add NH_4OH very slowly and with constant stirring until there is a slight excess. The NH_4OH must be free from CO_2. Filter hot and rapidly, and wash four times by decantation with hot solution of ammonium nitrate. Carefully wash the precipitate from the filter paper into a beaker, using hot water. Dissolve the precipitate in hot dilute HCl. Repeat the precipitation with NH_4Cl and NH_4OH. Decant four times as before, using hot ammonium nitrate. Transfer to the filter paper and wash with hot ammonium nitrate until the washings are free from chlorides when tested by silver nitrate. Evaporate the filtrate nearly to dryness, add a little NH_4OH and continue the evaporation. Keep the solution alkaline to coagulate any iron and aluminum hydroxides. Transfer the precipitate to a filter paper and wash thoroughly. Transfer the moist filter paper to the platinum crucible containing the resdiue from the silica. Burn off the filter paper and blast the precipitate. Repeat the blasting and weighing to a constant weight.

(15) Iron Oxide

To determine iron oxide, fuse the ignited alumina precipitate with about six times its weght of potassium pyrosulfate or potassium bisulfate. Avoid sputtering. Heat carefully to redness and continue heat-

ing until the residue is all dissolved. Cool. Dissolve in warm water and add about 10cc. of dilute H_2SO_4 (1:5). Evaporate to a small volume. Then heat to a higher temperature until copious fumes of H_2SO_4 are evolved. Sufficient H_2SO_4 should be present to form a pasty mass when cooled. Take up with water, filter off, wash, ignite and weigh the silica as before and evaporate with HF as before. The loss in weight is extra silica to be added to the original silica determination and subtracted from the alumina. Fuse the residue with a little potassium pyrosulfate or potassium bisulfate, and add the solution of this cake to the main solution. Transfer the total filtrate to a 250cc. graduated flask and dilute to 250cc. mixing thoroughly. Draw off 50cc. of this solution and reserve for titania determination. Pass the remaining 200cc. through a Jones reductor, or otherwise reduce the solution with pure zinc and H_2SO_4. To the solution add 3cc. of 10-per-cent $CuSO_4$ solution and titrate with standard $KMnO_4$ solution (1cc. equivalent to 0.001g. Fe_2O_3), until a faint pink tinge is seen. If Jones reductor or similar apparatus is used, subtract the $KMnO_4$ equivalent, which has previously been determined on blank samples run through the apparatus. From the result, calculate the iron as Fe_2O_3.

(16) Titania

To determine titania, place in a small Nessler tube the 50cc. of filtrate previously set aside for titania determination, and fill the tube up to the graduation mark. Add 1cc. of H_2O_2 (free from fluorine) and shake well. The color of this solution is now compared in any standard color comparator with the color of a known standard solution, preferably of such strength that 1cc. equals 0.0001g. if titanium dioxide (TiO_2). To make the comparison, put 10cc. of this standard solution into a second small Nessler tube and dilute with water from a burette until the color is matched. Note the amount of water added and calculate the percentage of TiO_2 in the sample.

(17) Lime

To determine lime, evaporate the filtrate from the alumina precipitation to about 250cc. While still boiling add about 5cc. of acetic acid. Meanwhile, dissolve about 1g. of oxalic acid in a little hot water and add to the solution. In about 5 minutes add a slight excess of NH_4OH and boil until precipitation is complete. Cool thoroughly and filter. Wash three times by decantation with dilute NH_4OH (1:10) or a 1% solution of ammonium oxalate. Dissolve the precipitate by adding about 50cc. of dilute HNO_3 (1:5). Again add a slight excess of NH_4OH and a few drops of oxalic acid solution. Boil well and let stand a couple of hours to cool. Filter and wash as before. Transfer the precipitate to a platinum crucible, carefully burn off the paper

and ignite over a blast lamp for about 10 minutes. Cool and weigh quickly. Repeat the blasting to constant weight. The increase in weight of crucible is calcium oxide.

(18) Magnesia

To determine magnesia, add to the filtrate from lime precipitation about 2g. of sodium-ammonium-phosphate dissolved in 15cc. of water. Stir vigorously and while stirring add drop by drop about one-third of the volume of the solution of NH_4OH. Let stand 12 to 24 hours. Filter and wash the precipitate with dilute NH_4OH (1 : 10). Discard the filtrate. Wash the precipitate until the washings show no discoloration when tested with silver nitrate. Redissolve the precipitate in warm dilute HNO_3 (1 : 5), using about 50cc. and collect in a beaker. Precipitate and wash as before. Collect the precipitate on a Gooch asbestos crucible. Dry slowly and then heat over a Meker burner for about 10 minutes; cool and weigh. Re-ignite to a constant weight.[1]

(19) Alkalies

To determine alkalies, the J. Lawrence Smith method shall be used. Weigh out about 0.5 g. of the sample and mix well with 0.5g. of NH_4Cl and 3g. of $CaCO_3$. Transfer to a platinum crucible, placing about 0.5g. of $CaCO_3$ in the bottom of the crucible and a similar amount over the top of the mixture. Heat gently over a low flame for about 15 minutes to volatilize NH_4Cl. Then raise the temperature until the lower three-quarters of the crucible is dull red. Hold this temperature for about one hour. Cool, take up with about 50cc. of water and heat over a water bath, adding water to replace that lost by evaporation. Break up any lumps with a small pestle. Decant the clear liquid through a filter paper and wash four times by decantation. Then transfer the residue to the filter. Wash until silver nitrate shows only a very faint turbidity. To the filtrate add NH_4OH and ammonium carbonate and heat to boiling. Filter and again digest the precipitate with NH_4OH and ammonium carbonate. Filter and allow the filtrate to collect with the previous filtrate, then evaporate to dryness in a platinum or porcelain dish. Remove ammonium salts by gentle ignition in a moving flame. Treat with water and remove the last trace of lime by adding ammonium oxalate to the boiling solution and let stand over night. Filter, evaporate to dryness, ignite gently and allow to cool. Then moisten the residue with HCl, evaporate again to dryness,

[1] The $Mg_2P_2O_7$ is never pure, being contaminated by small amounts of calcium, barium, aluminum, iron, manganese, etc., but in the analysis of refractories this error is negligible, and correction for these impurities is not required unless previously agreed upon.

ignite gently and weigh. Dissolve in water. Ignite and weigh any insoluble residue, deducting this from the alkali chlorides.

Dilute the solution of the mixed chlorides and add hydrochloroplatinic acid in amount equal to 0.3cc. more than would be necessary if all chlorides were present as NaCl. Evaporate to a syrupy consistency. Cool and treat with a few cubic centimeters of 80-per cent ethyl alcohol. Stir and decant through a weighed Gooch crucible. Treat again with 80-per-cent alcohol and decant. Repeat washing and decantation until the alcohol leaving the Gooch crucible is colorless and the precipitate appears golden yellow, not orange. Transfer the precipitate to the Gooch crucible, wash with 80-per-cent alcohol about six times and dry at 130°C. to constant weight. This residue is potassium chloroplatinate.

The oxides are calculated as follows:

Weight of potassium chloroplatinate x 0.3068 = KCl

Weight of potassium chloroplatinate x 0.1941 = K_2O

Total chlorides — KCl = NaCl

NaCl x 0.5303 = Na_2O

(20) Calculation of the Rational from the Ultimate Analysis

If it is desired to express the ultimate analysis in terms of rational analysis the following methods of calculation shall be followed:

Na_2O multiplied by 5.60 = SiO_2 in Na-feldspar

K_2O multiplied by 3.83 = SiO_2 in K-feldspar

Na_2O multiplied by 1.65 = Al_2O_3 in Na-feldspar

K_2O multiplied by 1.09 = Al_2O_3 in K-feldspar

Total Al_2O_3 in feldspar = Al_2O_3 in clay substance

Al_2O_3 in clay substance multiplied by 1.18 = SiO_2 in clay substance.

SiO_2 in quartz = total SiO_2 minus (SiO_2 in clay substance plus SiO_2 in Na- and K-feldspar).

Feldspar = (Na_2O multiplied by 8.45, plus K_2O multiplied by 5.92).

Clay substance = 100% minus (quartz plus feldspar).

TENTATIVE METHOD FOR SAG TESTS

Preface

The purpose of such a test as here defined is to determine the temperature and rate of softening under fixed conditions of load and heat treatment, as evidenced by transverse bending. For grogged mixtures that must support transversely applied load it supplies a direct test.

"Fine grog bodies" are understood as those containing grog finer than that which will pass a No. 20 sieve, and "coarse grog mixtures," those containing a grog of a coarser size, in any percentage.

Method for Clay and Fine Grog Bodies

(1) Shape and Size of Test Pieces

The test pieces shall be bars measuring 12mm. (½ inch) thick by 25mm. (1 inch) wide by 230mm. (9 inches) long when thoroughly dry.

(2) Making

The bars shall be made in plaster molds by casting the clay slip to such thickness that when dry it will be somewhat thicker than 12mm. (½ inch). This shall be allowed to dry slowly at room temperature until leather hard and then cut into strips somewhat wider than 25mm. (1 inch) and longer than 230mm. (9 inches). The oversize necessary will depend on the drying shrinkage of the clay. When thoroughly dry the bars shall be sized exactly by rubbing or scraping.

(3) Setting

The bars shall be set with the 25mm. (1 inch) dimension horizontal, in covered saggers. They shall rest on two fire clay knife edges spaced 177mm. (7 inches) apart.

(4) Knife Edges

It is recommended that the knife edges be triangular in cross-section and 45mm. (1¾ inches) high.

(5) Heat Treatment

The test kiln shall be of such size that the effective space available is not less than 1⅓ cubic feet.[1] The heating may be accomplished by any convenient means, but the temperature distribution should be thoroughly explored during the first few firings. A set of pyrometric cones of the Seger formulae as made by Professor Edward Orton, Jr., shall be placed as closely to the test pieces as possible, but temperature control by means of a platinum-platinum-rhodium thermo-

[1] A suitable test kiln is illustrated in the appendix.

couple is required also. It is obvious that the kiln must be fired separately for each heat treatment.

The heating shall preferably be at the rate of 45°C per hour from the start of the firing until a temperature of 800°C is reached and 20°C from that point until the end of the firing. In no case shall the rate of heating be greater than 60°C per hour nor less than 30°C per hour for the first period, or greater than 25°C per hour nor less than 15°C per hour for the last period.

(6) Number of Bars

Two bars of the same clay shall be set for each heat treatment. The number of heat treatments is optional, but for data upon which to base conclusions on rate of softening, at least five heat treatments at two cone intervals shall be made.

(7) Warpage Ratio

The amount of warpage shall be indicated by the ratio, to the second decimal place, of the amount of deflection in tenths of a millimeter to the span of 177mm. (7 inches), and shall be the average of two bars.

(8) Variation

If one bar shows a deformation more than 20% greater than the other, the test shall be considered faulty and the results discarded.

Method for Coarse Grog Mixtures

(9) Shape and Size of Test Piece

The test piece shall be 65mm. (2½ inches) square and 330mm. (13 niches) long when fired. A variation of plus or minus 3mm. (⅛ inch) is allowable in the cross-sectional dimensions.

(10) Making

The bars shall be made in a suitable mold for example as shown in Figure 12. The mixture shall be made up to soft plastic consistency and thrown forcibly into the mold, so as to completely fill out the lower corners. The first lump shall be thrown in the center and then the ends filled in a similar manner. The excess shall then be struck off with a wire and the top of the bar slicked off with a spatula and appropriately marked. The bars shall then be thoroughly dried and fired to at least one cone higher than that at which warpage is to be determined. Such care shall be taken in setting that no warpage or sagging occurs in this preliminary firing.

(11) Setting

The bars shall be set on flat fire clay supports with a span of 255mm. (10 inches) and loaded in the center with a fire clay stirrup having a knife edge support. The load shall be 4.5 kg. (10 pounds) for bars of exactly 65mm. (2½ inches) square cross-section. For bars within ± 3mm. (⅛ inch) of these dimensions, the load shall be calculated as follows:

$$P = 0.0185\ bd^2$$

where P = the load in kilograms
b = the breadth of the bar in centimeters
d = the depth of the bar in centimeters

or

$$P = 0.64\ bd^2$$

where P = the load in pounds
b = the breadth of the bar in inches
d = the depth of the bar in inches

(12) Heat Treatment

The heat treatment shall be the same as specified above for clay and fine grog bodies.

(13) Number of Bars

The number of bars shall be the same as specified above for clay and fine grog bodies.

(14) Warpage Ratio

The warpage ratio shall be calculated as already specified for clay and fine grog bodies.

(15) Variation

Allowable variation shall be the same as specified above for clay and fine grog godies.

TENTATIVE METHOD FOR TRANSVERSE STRENGTH

Preface

While a considerable amount of work has already been published in Transactions of American Ceramic Society on this subject, it is still not sufficient to allow of writing such definite specifications to cover this test as would be desired. However, the method which is presented below represents the best present practice, and will give quite consistent and reliable results as has elsewhere been shown.[1]

[1] See appendix for references on this subject.

Method

(1) Preparation of Clay

The clay shall be thoroughly dried at 64°C or above, but under 76°C, crushed and screened to pass a No. 20 sieve. It shall then be thoroughly mixed dry with an equal amount by weight of standard silica sand that passes a No. 20 sieve (Tentative Standard Series of Testing Sieves), and is retained on a No. 30 sieve. The mixture shall then be made up to soft plastic consistency with water and thoroughly pugged by hand.

(2) Shape of Test Piece

The test piece shall be made in a suitable metal or wooden mold. It shall be 17.5 cm. (7inches) long and have a 2.5 cm. (1 inch) square cross-section, in the plastic state.

(3) Forming

The mold shall be evenly and thinly oiled with kerosene and placed on a firm, smooth surface. A lump of the clay mixture, somewhat larger than is required to fill the mold shall be thrown forcibly into the mold so as to completely fill out the lower corners. The excess shall then be cut off with a spatula, and the top slicked off and appropriately marked. The marking should be near the ends, so as not to deform the center of the bar.

(4) Drying

The test pieces shall be allowed to dry under a cloth at room temperature for two days, then exposed at room temperature until air dry . During this period they shall be turned every twelve hours to make the drying more uniform. They shall then be placed in a drier operating between 64°C and 76°C for for at least five hours, and from there transferred to a drying oven, operating at 110°C, where they shall remain until approximately constant in weight.

(5) Breaking

The test pieces shall be cooled in a desiccator and then broken in a suitable machine, having knife edges with a 6mm. (¼ inch) radius and 12.5 cm. (5 inches) apart. The machine should have an automatic shutoff for the shot, and the rate of loading should be about 45 kg. (100 lbs.) per minute. The depth and breadth of the bar shall be taken at the break, and each shall be the average of three measurements taken to the nearest 0.25mm. (0.01 inch).

(6) Modulus of Rupture

The modulus of rupture shall be calculated by the formula

$$M = \frac{3\ Pl}{2\ bd^2}$$

where M = the modulus of rupture in kilograms per square centimeter
P = the breaking load in kilograms (read to the nearest 0.1kg.)
l = the distance between knife edges in centimeters
b = the breadth of the bar in centimeters
d = the depth of the bar in centimeters

or, if the English system is used, the units will be pounds and inches, and the modulus will be obtained in pounds per square inch, by the same formula.

Ten bars shall be broken and the average modulus of rupture reported. Two faulty test pieces are permissable in the case of which, the average of the eight or nine remaining shall be reported.

(7) Variation

A variation of plus or minus 15% from the average modulus of rupture is permissible. Test pieces showing a greater variation shall be considered faulty and discarded; but as indicated in Article 6 preceding, if more than two are thus discarded, the test shall be repeated.

TENTATIVE METHOD FOR SLAKING

Preface

The method here defined differs but little from the practice which is generally followed. The principal amendments are in the closer specifications on the size of screen and temperature of water. The latter particularly has a marked effect upon the slaking values obtained.

Method

(1) Test Pieces

The test pieces shall be cubes made of a mixture of 50% by weight of ground flint, and 50% of the clay to be tested which has been ground to pass a No. 30 sieve. (Tentative Standard Series of Testing Sieves). The flint shall be of the grade and fineness ordinarily termed "potter's flint" and shall all pass a No. 100 sieve (Tentative Standard Series of Testing Sieves). The cubes shall be 2.5 cm. (1 inch) no an edge in the wet state.

(2) Making the Test Pieces

The test pieces shall be made by pugging or working the mixture by hand to its best plastic consistency, batting out into a slab 2.5 cm. (1 inch) thick, cutting from this a strip 2.5 cm. (1 inch) wide and subdividing this strip into 2.5 cm. (1-inch cubes).

(3) Drying

The drying shall be accomplished in three stages, (a) at room temperature until air dry, (b) at a temperature between 64°C and 76°C for at least five hours, and finally (c) without allowing to cool to room temperature, at 110°C until approximately constant in wegiht. The test pieces shall then be cooled to room temperature in a desiccator.

(4) The Screen

The slaking shall be done on screens corresponding to a No. 2½ sieve (Tentative Standard Series of Testing Sieves).

(5) Water

The temperature of the water shall be held at 25°C ± 1°C, or 77°F ± 2°F.

(6) Slaking

After the samples are thoroughly dried and cooled (article 3) they shall be placed on a screen and carefully immersed in water, care being taken to prevent agitation of the water during the slaking operation. The water shall be at least 2.5 cm. (1 inch) deep under the test piece and the top of the piece shall be immersed in the water to a depth of not less than 1.2 cm. (½ inch) and not more than 2.5 cm. (1 inch).

(7) Report

The only data to be obtained is the time required in minutes for the whole of the test piece to slake and settle through the screen. The time reported shall be the average of two determinations.

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TENTATIVE STANDARD SCALE FOR TESTING SIEVE

Preface

The screen scale here defined was worked out by the Bureau of Standards in collaboration with a number of representative American technical societies, trade associations and manufacturers and users of screens. Its general adoption will mark a distinct advance in testing methods.

This screen scale is essentially metric. The sieve having an opening of 1mm. is the basic one, and the sieves above and below this in the series are related to it by using the fourth root of 2, or 1.1892 as the ratio of the width of one opening to the next smaller opening. In making selections from this series it is recommended that this be done on some systematic plan, as for example, the selection of every other sieve or of every fourth one in the series. In the former case the ratios of each opening to the next smaller one would be as $\sqrt{2}$:1, in the later case 2:1.

The proper designation of a sieve is the size of the opening, supplemented by the wire diameter, but it is well recognized that few users of sieves will be able to carry the sizes of the various openings in mind without reference to a printed table, and also that few users of sieves will be concerned with the exact sizes of the openings in either metric or English units. All the users of sieves desire to know in general is that the sieves are "standard," that is, that they conform to established specifications, and therefore the only designation required is a simple one which will suggest the degree of fineness or coarseness of the materal passing or retained upon any given sieve. Such a designation is an abstract number which is approximately the number of meshes per linear inch. The advantage of such a designation is readily apparent. Thus, the basic sieve in the series, which has a 1mm. opening, is given the number 18, which may be regarded simply as a fixed arbitrary number indicating that the sieve has approximately 18 meshes per inch. The fact that this sieve has actually 17.2 meshes per inch or 7 meshes per centimeter is of no importance; the number 18 merely indicates to those who are familiar with the old sieves what order of separation this sieve would give in testing any graded material.

(1) Designation

Screens shall be referred to by number only, as indicated in the table of fundamental data which follows:

(2) Size of Opening and Wire

The size of opening and the size of wire shall conform to the values and tolerances given below.

TABLE II

FUNDAMENTAL DATA RELATING TO SIEVES OF THE STANDARD SCREEN SCALE

Sieve No.	Sieve Opening Millimeters	Sieve Opening inches	Wire Diameter Millimeters	Wire Diameter inches	Tolerance in average Opening	Tolerance in Wire Diameter	Tolerance in maximum Opening	Mesh per cm.	Mesh per inch
2½	8.00	.315	1.85	.073	1%	5%	10%	1	2.6
3	6.72	.265	1.65	.065	1	5	10	1.2	3.0
3½	5.66	.223	1.45	.057	1	5	10	1.4	3.6
4	4.76	.187	1.27	.050	1	5	10	1.7	4.2
5	4.00	.157	1.12	.044	1	5	10	2	5.0
6	3.36	.132	1.02	.404	1	5	10	2.3	5.8
7	2.83	.111	.92	.036	1	5	10	2.7	6.8
8	2.38	.094	.84	.033	2%	5%	10%	3	7.9
10	2.00	.079	.76	.030	2	5	10	3.5	9.2
12	1.68	.066	.69	.027	2	5	10	4	10.8
14	1.41	.0557	.61	.024	2	5	10	5	12.5
16	1.19	.0468	.54	.021	2	5	10	6	14.7
18	1.00	.0394	.48	.0187	2	5	10	7	17.2
20	.84	.0331	.42	.0165	3%	5%	25%	8	20.2
25	.71	.0278	.37	.0146	3	5	25	9	23.6
30	.59	.0234	.33	.0129	3	5	25	11	27.5
35	.50	.0197	.29	.0113	3	5	25	13	32.3
40	.42	.0166	.25	.0098	3	5	25	15	37.9
45	.35	.0139	.22	.0085	3	5	25	18	44.7
50	.30	.0117	.188	.0074	4%	10%	40%	20	52.4
60	.25	.0098	.162	.0064	4	10	40	24	61.7
70	.21	.0083	.140	.0055	4	10	40	29	72.5
80	.177	.0070	.119	.0047	4	10	40	34	85.5
100	.149	.0059	.102	.0040	4	10	40	40	101.
120	.125	.0049	.086	.0034	4	10	40	47	120.
140	.105	.0041	.074	.0029	5%	15%	60%	56	143.
170	.088	.0035	.063	.0025	5	15	60	66	167.
200	.074	.0029	.053	.0021	5	15	60	79	200.
230	.062	.0025	.046	.0018	5	15	60	93	233.
270	.053	.0021	.041	.0016	5	15	60	106	270.
325	.044	.0017	.036	.0014	5	15	60	125	323.

Note: In order to utilize cloth now on the market, it will be permissible, until notice is given to the contrary, to use wire whose diameters is within a tolerance of 10% for the first three groups and 20% for the last two groups.

(3 Shape and Size of Sieves

The screens shall conform to the following requirements as to size and design:

(a) They shall be of sufficient depth to minimize the loss of material during test.

(b) The total height of sieve and pan shall be such as to allow the operator to hold the combination firmly in one hand without undue fatigue during test.

(c) The sieve and pan shall be of copper or brass and seamless, and sufficiently strong and rigid to stand ordinary laboratory treatment.

(d) All crevices in sieve, pans, and covers where material might lodge shall be smoothly soldered.

(e) Standard testing sieves shall be preferably 20 cm. in diameter, this being the inside dimension of top of sieve, and outside dimension of bottom of sieve.

(f) Covers, sieves and nesting pans shall fit loosely, and not tightly, and shall have rims of sufficient depth to prevent accidental loss of material during test.

TENTATIVE DEFINITIONS FOR CLAY REFRACTORIES

(These definitions are the same as those issued by the American Society for Testing Materials under the serial designation C27-20, except for slight amendments to paragraphs 2 and 3.)

1. The following definitions relating to the resistance to heat and the constancy of volume of clay refractories are recommended for the purpose of classification.

2. The softening point referred to in the following definitions shall be determined in accordance with the Standard Method for Softening Point of the American Ceramic Society, or the Standard Test for Softening Point of Fire-Clay Brick (Serial Designation: C24) of the Amercan Society for Testing Materials.

3. The test for linear contraction or expansion referred to in the following definitions shall be conducted in accordance with the method for volume change described in the Standard Method for Behavior in Firing of the American Ceramic Society; the linear values being calculated from the volume changes as described in the Standard Method for Drying Shrinkage of the American Ceramic Society.

DEFINITIONS FOR CLAY REFRACTORIES

I. High Heat Duty Brick

(a) Clay Fire Brick

(Silica content less than 70 per cent)

4. The softening point of clay fire brick for high heat duty shall not be lower than that of standard cone No. 31 (about 1685° C., or 3065° F.).

5. When duplicate samples of clay fire brick for high heat duty are heated uniformly in a suitable furnace to a temperature of 1400° C. (2252° F.), maintained at this temperature for 5 hours, and cooled, they shall not show a contraction of more than 1.5 per cent of the original length nor an expansion of more than 1 per cent.

6. When a brick of this type softens at a temperature not below the softening point of standard cone No. 29 (about 1650° C., or 3002° F.), it may be tested according to classification (b) for silicious clay fire brick without losing in standng if it passes the tests.

(b) Silicious Clay Fire Brick

(Silica content 70 per cent or over)

7. The softening point of silicious clay fire brick for high heat duty shall not be lower than that of standard cone No. 28 (about 1635° C., or 2975° F.).

8. All silicious clay fire brick for high heat duty shall be subjected to a load test in accordance with the requirements of the Standard Test for Refractory Materials under Load at High Temperatures (Serial Designation: C 16) of the American Society for Testing Materials.[1] The pressure to be applied upon the brick (placed on end) shall be 25 lb. per sq. in. and the maximum furnace temperature 1350° C. (2462° F.). The brick shall not show a contraction of more than 4 per cent of the original length, nor an expansion of more than 1 per cent.

9. When duplicate samples of silicious clay fire brick for high heat duty are heated uniformly in a suitable furnace to a temperature of 1400° C. (2552° F.), maintained at this temperature for 5 hours, and cooled, they shall not show a contraction of more than 1.5 per cent of the original length nor an expansion of more than 1 per cent.

II. Intermediate Heat Duty Brick

10. The softening point of brick for intermediate heat duty shall Not be lower than that of standard cone No. 28 (about 1635° C, or 2975° F.).

[1] A. S. T. M. Standards adopted in 1920.

11. When duplicate samples of brick for intermediate heat duty are heated uniformly in a suitable furnace to a temperature of 1350° C. (2462° F.), maintained at this temperature for 5 hours, and cooled, they shall not show a contraction of more than 1.5 per cent of the original length nor an expansion of more than 1 per cent.

III. Moderate Heat Duty Brick

12. The softening point of brick for moderate heat duty shall not be lower than that of standard cone No. 26 (about 1600° C., or 2912° F.).

13. When duplicate samples of brick for moderate heat duty are heated uniformly in a suitable furnace to a temperature of 1290° C. (2354° F.), maintained at this temperature for 5 hours, and cooled, they shall not show a contraction of more than 1.5 per cent of the original length nor an expansion of more than 1 per cent.

IV. Low Heat Duty Brick

14. The softening point of brick for low heat duty shall not be lower than that of standard cone No. 19 (about 1510° C., or 2750° F.).

TENTATIVE METHODS OF TESTING ELECTRICAL PORCELAIN

(These methods have been issued by the American Society for Testing Materials under the serial designation D116-21T.)

1. These tests are intended to apply to porcelain which is to be used for electrical insulating purposes.

Tensile Strength

2. Any standard testing machine may be employed, but it shall be of suitable capacity.

3. Test specimens may be prepared by pugging or extruding rolls of suitable size, throwing rolls by hand or by cutting rolls from pugged blocks. For comparative tests one method of preparing specimens should be adhered to, as test specimens prepared by different processes show diffrent results. They shall be turned in the green condition to such dimensions as will give fired pieces of standard size, shrinkage being determined and allowed for as in regular ceramic practice. Variation from the standard dimension shall be kept within $\pm$ 5 per cent, as it has been found that the strength per square inch calculated from results obtained with test specimens of about 0.2 sq. in. increases about 0.5 per cent for a decrease in area of 1 per cent.

Test specimens shall be fired in saggers on end, either on placing sand or clay bats. They shall not be buried in sand as this will cause

the pieces to break in firing. Firing shall be carried out in the regular porcelain kilns. Specimens which have warped in firing shall be rejected because they will give unreliable results and therefore a sufficient number of specimens should be prepared to give the required number of satisfactory ones.

4. (a) **Ohio Brass Co. Method**—The test specimens shall have the shape and dimensions shown in Fig. 1.

(b) **Jeffry-Dewitt Insulator Co. Method**—The test specimens shall have the shape and dimensions shown in either Fig. 2 or Fig. 3. The maximum cross-section area in the reduced section of the specimen shall be not greater than 0.2 sq. in.

When dry, the shoulder of the specimens shall be glazed, leaving the reduced section free from glaze.

Note—The glaze is necessary to obtain uniform results and insure that failure occurs in testing in the reduced section. The glaze is omitted from the reduced section in order to avoid variation in strength which may be attributable to the glaze.

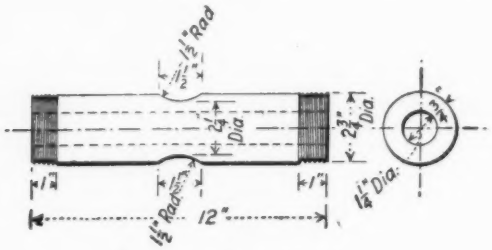


Fig. 1

5. (a) **O.B. Method**—The method of mounting the test specimen in the specimen holders is shown in Fig. 4. The method of using the assembly jig shown in the figure is as follows: The test specimen is calipered at the small section. The tapered jig, G, with the arbor, E, is then placed in the guides, V. The point on the tapered piece, G, which has the same diameter as the minimum section on the specimen is placed directly over the V-notched block, N. This piece is then raised until it comes in contact with the piece, G, and the wing nut, S, tightened. E and G are then removed and the cap pieces, C, screwed on to the rods, R, which are laid in the notches V-V. The center of the specimen is placed in the V-notched block, N, and the clamping piece, L, tightened down to hold it in place.

One of the caps, C, with the attached Rod, R, can be moved over the end of the specimen and held in place by tightening the strap, H; the whole assembly apparatus is then stood on one end and the cap

moved so as to allow filling with cement. The cap is then moved up in place, rotating it at the same time so as to properly work in the cement. The strap, H, is then tightened and the piece left undisturbed until the cement hardens.

When the cap has been attached at one end, the assembly apparatus can be stood on the other end and the other cap cemented in place.

When the cap has been attached at one end, the assembly apparatus can be stood on the other end and the other cap cemented in place.

Note—This arrangement permits of setting up the jig properly and easily for specimens which vary slightly in diameter and insures keeping the center line of the specimen in the center line of the caps. A slight tip of the specimen will be unimportant so long as both caps can be assembled to the specimen.

After the cement has hardened (which will not require more than five or ten minutes if litharge cement is used), the specimen can be removed and eyes screwed into caps in place of the rods, R.

(b) J-D Method—The method of mounting the test specimen in this method of testing is as follows:

Test Specimen, Fig. 2 (Conical Ends)—The specimen shall be held by small steel clamps, Fig. 5, each consisting of a split bushing,

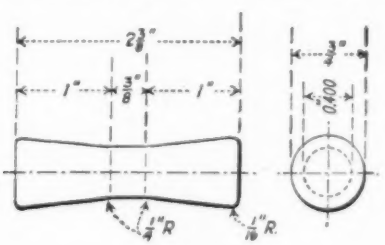


Fig. 2

B, ground to fit the test specimen, T, and held by a collar, C, the load being applied by the plate, P_1, held in slots of the jaws of the testing machine through the ball and socket joint, J. The soft gasket, G. of blotting paper shall be inserted between the porcelain and the bushing to distribute the load. A new gasket shall be used with each specimen.

Test Specimen, Fig. 3 (Dumb-bell Ends)—The specimen is held by a split ring, R, Fig. 6, with the same radius of curvature as the shoulders of the specimen. This ring fits into a recess in plate P_2 which, in turn, fits into the slots in the jaws of the testing machine.

Note—No gasket is required with this piece when the shoulders are glazed. Satisfactory results have not been obtained with unglazed pieces, even when using a gasket. This form of specimen has the advantage of requiring no gasket and so is more rapid in manipulation and of allowing greater variation in dimensions.

6. (a) Not less than 10 specimens (preferably more) shall be tested in the normal condition.

(b) The specimen shall be pulled apart at such a constant speed that the beam of the testing machine can be kept well balanced at all loads.

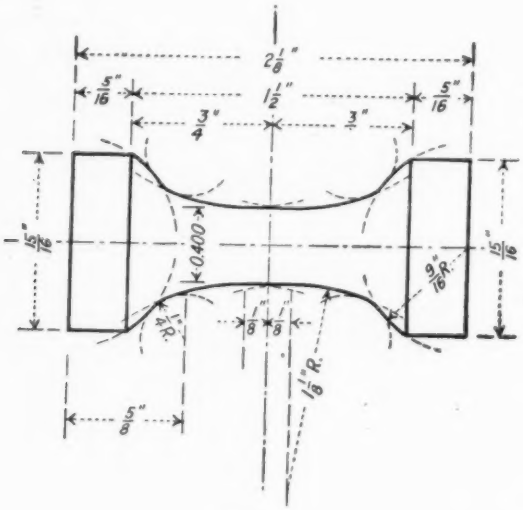


Fig. 3

(c) When failure occurs outside of the reduced section, that result shall be discarded.

(d) The tests shall be made at a room temperature of about 20° C. (68° F.).

7. The report shall include the following:

(a) The diameter in inches or centimeters as measured by a micrometer at the point of fracture.

(b) The breaking load of each specimen in pounds or in kilograms.

(c) The ultimate strength in pounds per square inch or in kilograms per square centimeter of each specimen as calculated from the actual area of the specimen measured at the point of fracture.

(d) The average of the results given in Paragraph (c).

(e) The character of the material tested and a description of its behavior under stress.

(f) The speed in inches or centimeters per minute at which the jaws traveled during the test.

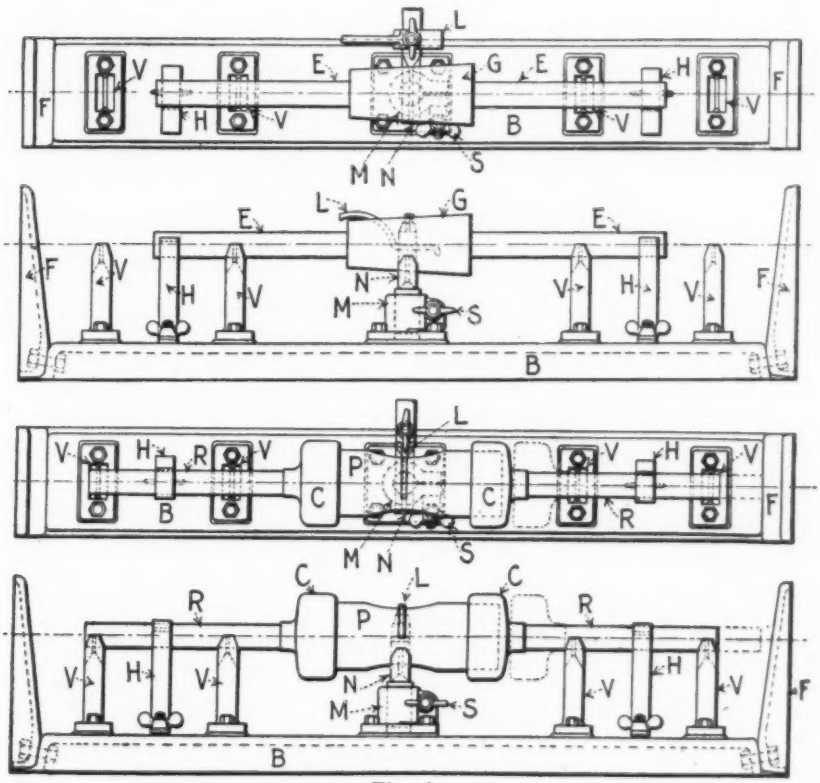


Fig. 4

Compressive Strength

8. Any standard testing machine may be used. A contact pad or cushion of $\frac{1}{32}$ in. of blotting paper shall be placed between the upper and lower faces of the specimens and the heads of the testing machine to equalize irregularities in the surfaces. Fresh cushions shall be used for each specimen tested.

9. The test specimen shown in Fig. 7 shall be used for the compressive strength test.

10. (a) Not less than 10 specimens (preferably more) shall be tested in the condition in which they are received.

(b) The load shall be applied at that constant rate of speed which will permit the beam to be kept well balanced at all loads.

(c) The test shall be made at a room temperature of about 20° C. (68° F.).

11. The report shall include the following:

(a) The diminsions of each specimen in inches or in millimeters.

(b) The load in pounds or kilograms on each specimen at the first sign of fracture.

(c) The ultimate compressive strength in pounds per square inch or in kilograms per square centimeter for each specimen calculated from the measured area before the load is applied.

(d) The average of the results given in Paragraph (c).

(e) General character of the material tested and a description of its behavior under load.

(f) The speed in inches or in centimeters at which the jaws traveled during the test.

Resistance to Impact

12. The test shall be made with the apparatus shown in Fig. 8.

13. The test specimen shown in Fig. 7 shall be used for impact tests.

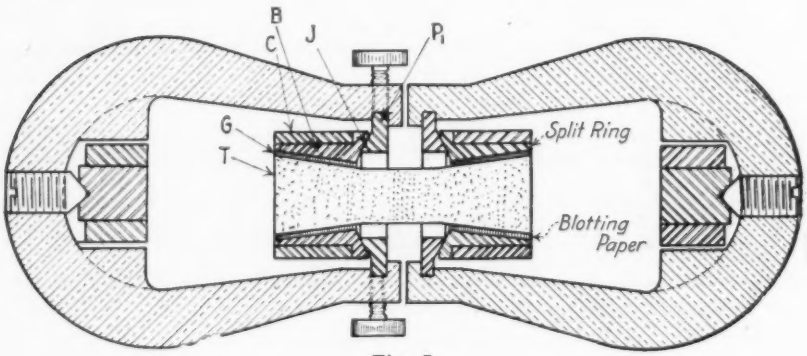


Fig. 5

14. (a) The specimen shall be placed on the base of the device directly under the hammer with a disk of blotting paper on the top of the specimen. The collars shall be set for a 6-in. drop of the hammer. The hammer shall be raised to the stops and allowed to fall unimpeded upon the specimen. A fresh disk of blotting paper shall be used for each blow of the hammer.

(b) The entire hammer shall weigh 1.87 lb. (850 g.).

(c) If the specimen remains unbroken after 20 blows of the hammer, using the 6-in. drop, the drop shall be increased to 7 in. and the test repeated. If the specimen remains unbroken after 20 blows using the 7-in. drop, the distance shall be increased to 8 in. and the test repeated. If necessary, increasing the height 1 in. per 20 blows shall be continued until the specimen breaks.

(d) Not less than five specimens shall be tested in the condition in which they are received.

15. The report shall include a statement of the number of blows required to break each specimen with a 6-in. fall of the hammer or, if failure did not occur with the 6-in. drop, the total number of blows and heights of drop necessary to fracture each specimen.

Dielectric Strength

16. The apparatus shall be as described in Section 14 of the Tentative Tests for Molded Insulating Materials (Serial Designation: D 48-17T) of the American Society for Testing Materials.[1]

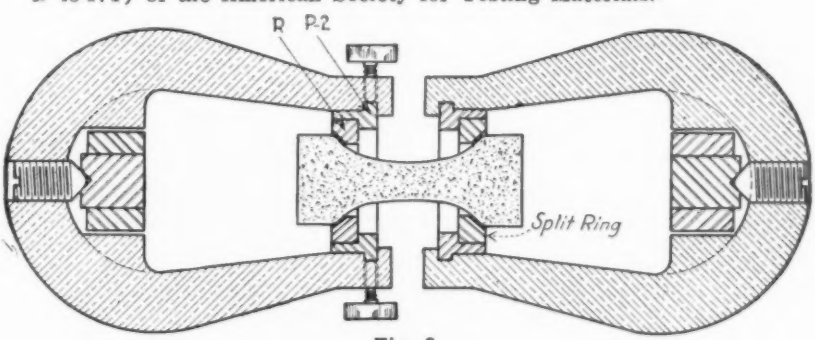


Fig. 6

17. The specimens shall be as shown in Fig. 1, except that the threads may be omitted.

18. (a) **Porcelain for all purposes**—A pad of wet clay about ¼ in. thick shall be laid in the groove and a lining of wet clay about ¼ in. thick put on the inside of the specimen. The potential shall be applied to these two pads of clay by any suitable means. Mercury may be substituted for the wet clay if desired. The test should preferably be made in air, but it may be made in transformer oil if necessary.

Not less than ten specimens shall be punctured in their normal condition at a normal room temperature of about 20° C. (68° F.).

[1] **Proceedings**, Am. Soc. Test. Mats., Vol. XX, Part I, p. 776 (1920).

(b) **Porcelain for transmission line insulators**—In addition to the test described in Paragraph (a), not less than 10 spceimens shall be tested in the same manner at a temperature of 75° C. (167° F.).

(c) **Porcelain for spark plugs**—In addition to the test prescribed in Paragraph (a), not less than 10 specimens shall be tested to determine the effect of high temperatures on the dielctric strength. The specimens shall be placed in an electrically heated oven, the temperature of which shall be raised at a constant rate to 600° C. (1112° F.). A given voltage shall be applied and maintained constant and the temperature raised at any constant rate such that the porcelain is always practically at the temperature of the air. The temperature shall be raised until puncture occurs.

(d) Whenever a puncture occurs at a point other than the minimum section of the specimen in any of the tests prescribed above, that result shall be discarded.

19. The report shall include the following:

(a) A statement of the purpose for which the porcelain is intended and the kind of tests which were made.

(b) The thickness of the specimen at the bottom of the groove.

(c) The voltage at puncture for each of the test specimens, together with the average, maximum and minimum volts per mil or per millimeter of thickness.

Resistance to Thermal Change

(A) Porcelain for Transmission Line Insulators

20. The apparatus shall consist of a hot water bath maintained at a temperature of 100° C. (212° F.) and an ice water bath maintained at 0° C. (32° F.).

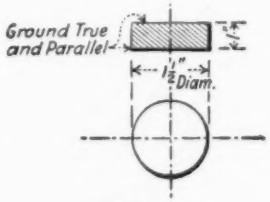


Fig. 7

21. The test specimens shall be as shown in Fig. 1.

22. (a) The test specimen shall be immersed in the ice water bath for ten minutes and then transferred as quickly as possible to the hot water bath, and allowed to remain there for ten minutes. The specimen shall be transferred back to the cold water and the cycles continued until the specimen breaks.

(b) Not less than five specimens shall be tested.

23. Report the number of cycles necessary to cause fracture of each test specimen.

(B) Porcelain for Spark Plugs and Heating Devices

24. A furnace in which a temperature of 900° C. (1652° F.) can be obtained and any suitable testing machine for determining the transverse strength of small beams may be used.

25. The specimens shall be as shown in Fig. 3.

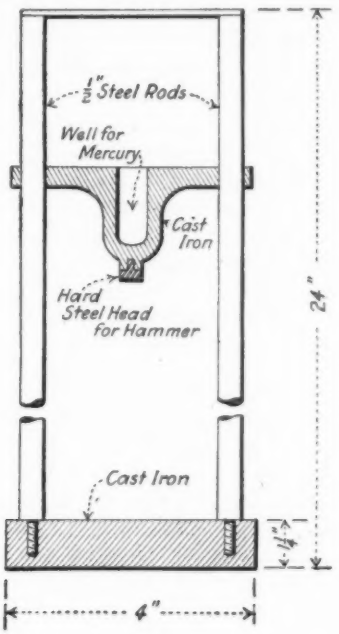


Fig. 8

26. (a) One-half of not less than 12 specimens shall be taken and placed in the furnace. The rate of heating shall be so adjusted that the temperature reaches 900° C. (1652° F.) in two hours. The furnace shall then be allowed to cool at such a rate that room temperature is reached in four hours.

(b) All specimens for transverse strength shall be tested by placing them on supports 6 in. apart and loading them at the center.

27. The report shall include the following:

(a) The load in pounds or kilograms reqired to break each specimen not subjected to heat treatment, together with the average.

(b) The load required to break each specimen that was subjected to heat treatment, together with the average.

(c) The percentage loss of strength due to heat treatment calculated from the two averages.

Porosity

(A) Moisture Absorption

28. Any good chemical balance, a beaker of distilled water at normal room temperature of about 20° C. (68° F.) and an oven of any standard make capable of maintaining a uniform temperature at the desired point within ± 5° C. shall be provided.

29. A single piece of porcelain shall be used weighing from 30 to 50 g. and with at least 50 per cent of the surface newly fractured.

30. The specimen shall be dried for 24 hours at 120° C. (248° F.), cooled in a desiccator and weighed. The specimen shall then be totally submerged in the distilled water at room temperature (about 20° C.) and allowd to remain submerged for 100 hours. The water shall be boiled for approximately one hour during the first, twenty-fifth, forty-ninth and seventy-third hours. The specimen shall be removed at the end of the 100-hour period, the surface moisture carefully dried off with a clean, dry cloth and the specimen weighed.

31. The report shall include the following:

(a) The original weight of the specimen.

(b) The dry weight of the specimen.

(c) The dry weight of the specimen after immersion for 100 hours.

(d) The percentage of moisture content in each specimen as received and the percentage of moisture absorbd during 100 hours, taking the dry weight as 100 per cent, and the average where more than one specimen is tested.

(B) Penetration of Dye

32. A closed receptacle containing an alcoholic dye solution and a pump with which a pressure up to 600 lb. per sq. in. can be maintained in the receptacle shall be provided.

33. A single specimen of porcelain shall be used, weighing at least 30 g. and with at least 50 per cent of the surface newly fractured. This specimen may be taken from any piece of finished ware, but if the piece varies materially in thickness (as, for example, in a transmission line insulator), a specmen shall be taken from both the thinnest and the thickest portions.

34. The specimen shall be immersed for two hours in a saturated methol alcoholic solution of eosin or fuchsine at a pressure of not less than 200 lb. per sq. in nor more than 600 lb. per sq. in. at a room temperature of about 20° C. (68° F.).

35. The report shall include a statement of the maximum depth of penetration of the dye toward the interior of the specimen from the fractured surface exposed to the solution. (Lines of penetration along obvious cracks caused by possible fracturing are to be disregarded.)

TENTATIVE METHOD OF TEST FOR REFRACTORY MATERIALS UNDER LOAD AT HIGH TEMPERATURES

(This test has been issued by the American Society for Testing Materials under the serial designation C16-20.)[1]

1. The object of this test is to determine the resistance of the specimen to deformation at a specified temperature for a specified time, when subjected to a compressive load of 25 lb. per sq. in. (1.765 kg. per sq. cm.).

2. The apparatus consists essentially of a furnace and loading device. It shall be constructed in accordance with Fig. 9 and 10.

(a) The furnace shall be cylindrical in form, 18 in. (457 mm.) in internal diameter, as shown in Fig. 9.

(b) The heating shall be done with gaseous or oil fuel and compressed air, using not less than two burners located tangentially and so arranged that no flame can impinge upon the test specimen. The burners shall be such as will insure a universal temperature in all parts of the furnace and be under complete control.

(c) The method of loading shown in Fig. 9 shall be used, and the details shall be such as will insure accuracy in the applied load and freedom from eccentric loading, both in the original application and during the testing. It is advantageous to make the cross-beams as light as possible, so that the greater portion of the load may be concentrated in the weights.

[1] A.S.T.M. Standards, 1921 issue, page 617.

TABLE III

TEMPERATURE TO BE ATTAINED AT TIME SPECIFIED

All Temperatures in Degrees Centigrade.

Time Hr.	Min.	Silica	Fire Clay: Heavy Duty	Fire Clay: Moderate Duty	Fire Clay: Light Duty
	15	40	160	160	160
	30	80	280	280	280
	45	140	400	400	400
1	0	200	500	500	500
	15	260	620	595	570
	30	290	720	685	640
	45	300	815	770	700
2	0	310	900	850	755
	15	320	980	920	810
	30	385	1045	990	860
	45	490	1100	1050	905
3	0	590	1150	1100	950
	15	695	1195	1145	985
	30	800	1235	1185	1020
	45	900	1270	1220	1050
4	0	1000	1300	1250	1075
	15	1100	1330	1275	1090
	30	1200	1350	1300	1100
	45	1250	1350	1300	1100
5	0	1300	1350	1300	1100
	15	1350	1350	1300	1100
	30	1380	1350	1300	1100
	45	1410	1350	1300	1100
6	0	1440	1350 (End)	1300 (End)	1100 (End)
	15	1470			
	30	1500			
	45	1500			
7	0	1500			
	15	1500			
	30	1500			
	45	1500			
8	0	1500 (End)			

(d) The temperature may be measured either with a calibrated platinum-rhodium thermo-couple, encased in a double protecting tube with the junction not more than 1 in. (25 mm.) from the side or edge of the specimen and approximately opposite the center; or with some form of optical pyrometer that has been calibrated against a thermo-

couple in the furnace. If the thermo-couple is used, the cold-end temperature should be kept constant in melted ice. A recording form of indicator is recommended where possible.

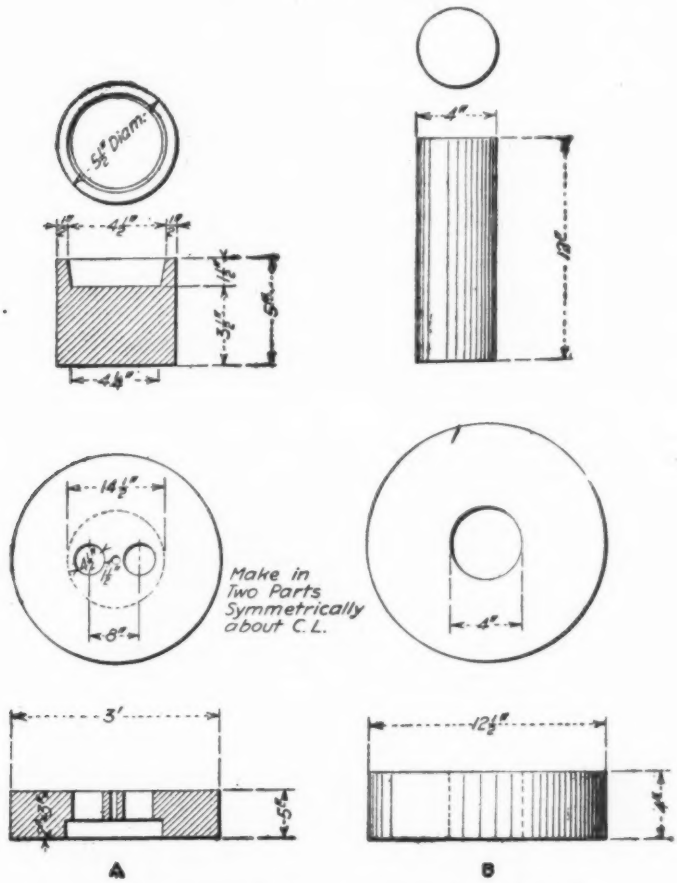


Fig. 10.—Special Shapes Required for Furnace.
(By courtesy of Metallurgical and Chemical Engineering.)

3. The test specimen shall consist, whenever possible, of a standard 9-in. brick placed vertically on end. In the case of blocks or shapes, sections approximately 9 by 4½ by 2½ in. (228 by 114 by 64 mm.) shall be cut, utilizing as far as possible existing plane surfaces. The ends of the specimen shall be either ground so that they

are parallel and perpendicular to the vertical axis, or if this is impossible, shall be bedded in a neutral cement, so that the specimen is perpendicular to the base of the furnace.

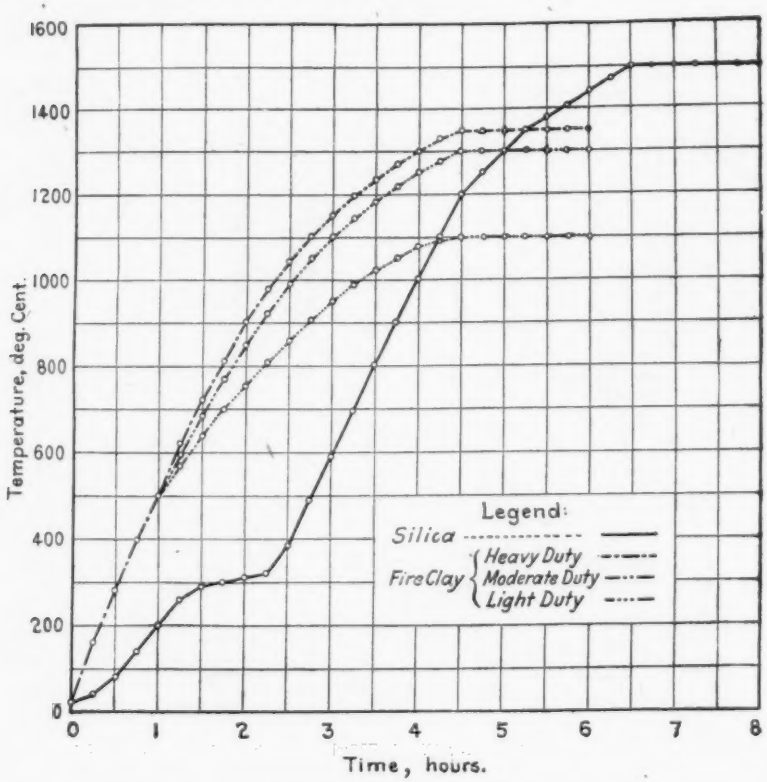


Fig. 11.—Time-Temperature Curve for Load Test.

The test specimen shall be measured before testing, making not less than five observations in each direction to within ± 0.02 in. (0.5 mm.). The average dimensions shall be reported, and the cross-section calculated.

4. The test specimen shall occupy approximately the center of the furnace and should rest on a block of some highly refractory material, having a minimum expansion or contraction. A silicon-carbide brick has been found satisfactory. At the top of the test specimen a block of similar highly refractory material should be placed, extending through the furnace top to receive the load.

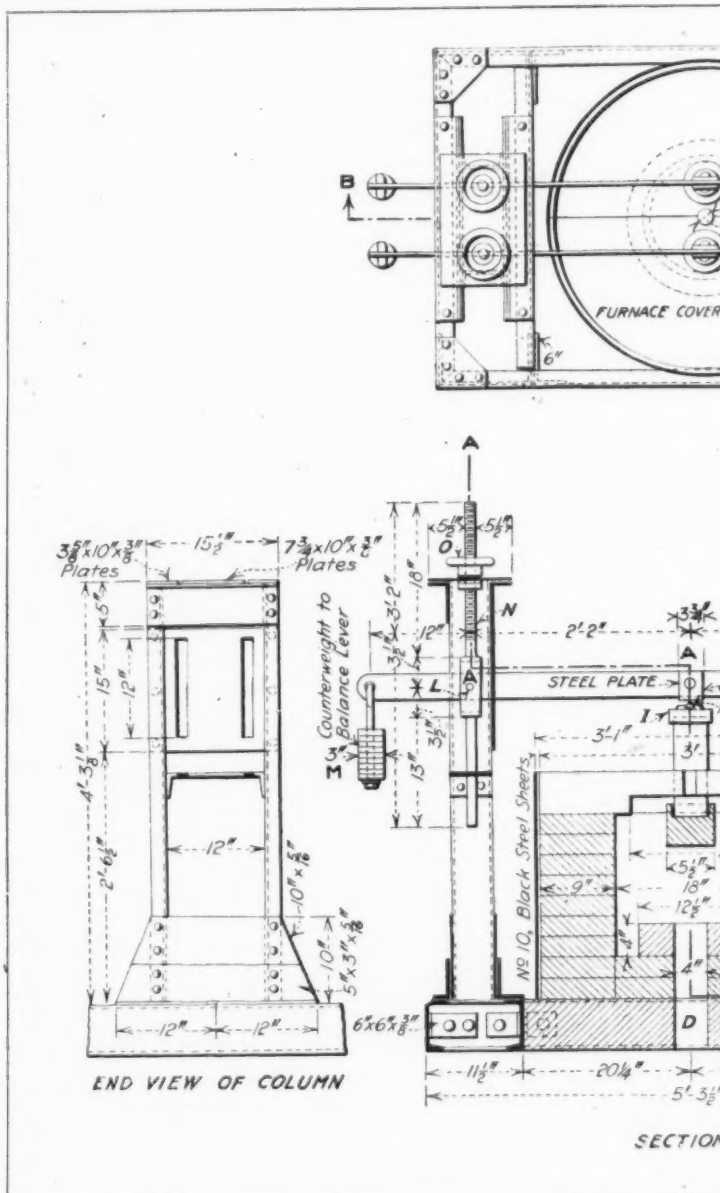
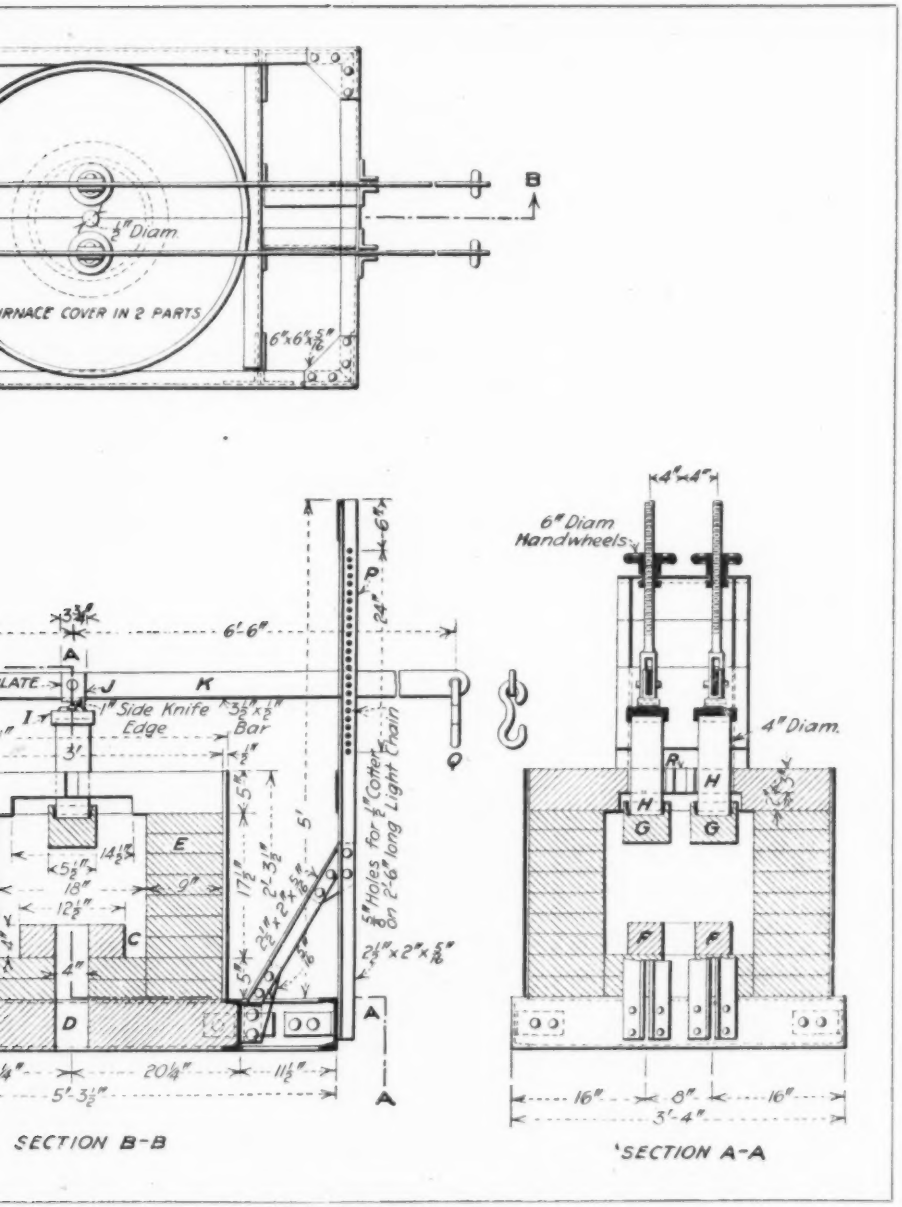


Fig. 9.—Apparatus for Testing Refracto



Refractory Materials under Load at High Temperatures.

(By courtesy of Metallurgical and Chemical Engineering.)

Note.—Gross error which may more than double the contraction will result if the specimen is not set perpendicular to the base of the support or if the load is eccentrically applied.

5. The rate of heating shall be in accordance with the requirements of Table III and the time-temperature curves of Fig. III, which give the rate and time of heating suggested for different grades of material.

6. (a) The load is calculated from the average cross-section as determined on the untested specimen and the requirement of the test. It is recommended that for general purposes, 25 lb. per sq. in. (1.765 kg. per sq. cm.) be used.

(b) The additional masses required to give the desired loading should be equally distributed on each side of the beam.

7. (a) At the expiration of the time of heating, the supply of heat shall be stopped and the furnace allowed to cool, during not less than 5 hours before removing the load and examining the test specimen.

Note.—The specimen shall be examined immediately after the heating is stopped for evidences of cracking and spalling, as such defects may develop later due to the rapid cooling of the furnace.

(b) After the test specimen has cooled to the room temperature, it shall be remeasured as before described, and the change in length recorded and reported as percentage of the original length.

Note.—It is recommended that a photograph be made of the specimen before and after testing, as yielding valuable information at a minimum time and expense.

APPENDIX

I. CLAY

1. Size and Shape of Test Piece

The test piece is made 30 x 30 x 45 mm. (1⅛ x 1⅛ x 1⅞") for a definite reason. It is about as large as it can be made and have a plastic volume less than 50cc. If the volume is greater than 50cc it necessitates the use of larger burettes which are cumbersome and more easily broken. It is also a convenient size for handling in placing in a volumeter as well as placing in the kiln for draw trial burning. If any longer, the total number that could be placed in the kiln would be cut down. If any larger in cross section they would be inconvenient in handling in the kiln, particularly if tongs were used.

2. Making Test Pieces

Figure 12 shows a metal mold suitable for use in forming the test pieces. The length may be altered but it has been found that it is preferable to make the bars as long as possible and then to cut them into pieces of the proper length for test. This method gives a more uniform structure through the entire cross section.

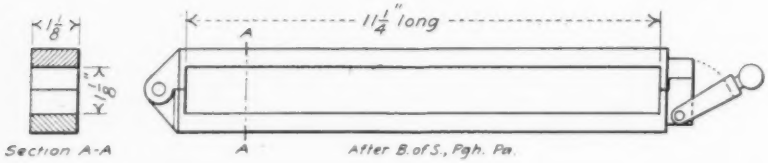
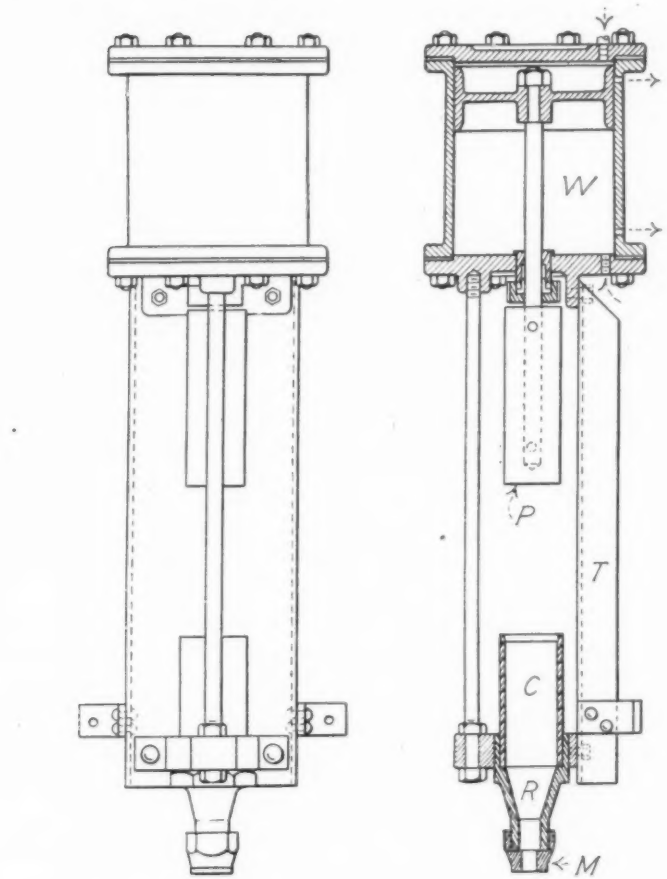
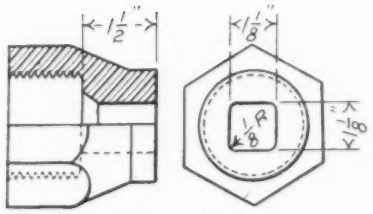


Fig. 12.

The cutting may be facilitated by having a small miter box into which the plastic clay bar is placed, always keeping it on the small pallett on which it was made, and cutting it into the proper length with a fine steel wire stretched on a suitable frame. It is also advantageous to pick the soft test pieces up without injuring them. This can be done very well by using thin strips of wood or metal the length of the test piece and as wide as the test piece is high. Use one on each side of the piece and press them gently until the piece can be lifted between them.

This method of cutting and handling should also be used in making machine made bars. Figure 13 illustrates a type of hydraulic plunger piston press that is being used successfully for this purpose.





DETAIL OF MOUTHPIECE

W - C.I. Cylinder, 10" in. dia.
P - Plunger, $3\frac{1}{2} \times 11\frac{1}{8}$
T - 10" Channel
C - Clay Cylinder, $3\frac{1}{2}$" × 8"
R - Reducer, $3\frac{1}{2}$ to $1\frac{1}{2}$ dia.
M - Mouthpiece

Fig. 13

In using this press care should be taken in wedging the clay and making it up into a reasonably true cylindrical shape so that it can be placed down into the clay cylinder without trapping air.

A small Mueller or other auger machine fitted with a 30 mm. by 30 mm. die also works very satisfactorily but extreme care should be taken to avoid laminations.

With very plastic and sticky clays a light machine oil does not give relief from sticking to the mold. In such cases a heavy oil or even grease may be found necessary.

It is recommended that the draw trials be marked in sequence for convenience in handling the pieces in testing. Each test piece should have its laboratory number clearly stamped on it and the number of the piece as well. Example, Lab. No. 246, Specimen Nos. 1, 2, 3, etc.

3. Plastic Volume

It is advisable, with all volumeters to run check determinations at least once an hour, but to check the first test made the previous hour. The design of the shape of the test piece is such that the plastic volume is less than 50cc. This overcomes using large and cumbersome burettes. The volumeters should preferably be designed as small in cross section as possible and still permit convenient handling of the test pieces.

There are several volumeters of the displacement type which may be used. Kerosene is specified as the measuring fluid both for plastic and dry volumes as it is not possible to use water. The reason for this is evident as the unfired clay would easily disintegrate in the water. On account of its changing in volume with changes in temperature, care should be used to maintain constant temperatures, at least during a complete operation.

Water is used in determining the volumes on the burned pieces. Kerosene could be used but it would necessitate drying out the water saturated test pieces and re-saturating them in the kerosene.

For the above reasons it is advisable to have two volumeters, one for each liquid if many tests are to be run as it is considerable trouble to clean the meter out.

In operating all volumeters, care should be taken in handling the test pieces to be sure that they are properly drained both before placing in the meter and after removing. There is bound to be some error due to imperfect removal of the liquid so that care should be used in handling all pieces in as nearly the same manner as possible so that the error will be constant.

The pieces to be measured are immersed in the liquid until ready to test. It has been found convenient to allow each test piece to drain

on a small screen frame over a cup for the time required to measure one other piece. This works out very well and the time interval is fairly uniform. Each piece after draining is gently pressed against a damp towel to remove any extra liquid before it is placed in the volumeter.

In removing the test piece the reason for draining is only to prevent the necessity of adding more fluid to the volumeter. Keeping track of this loss gives a good guide as to the accuracy of the instrument.

Figure 14 illustrates a volumeter of the Seger type as designed by Bleininger. It is designed to read up to 50cc while the regular meter reads to 100cc. It also has the advantage of having the stopper made with as small a diameter as possible and still allow clearance for the 1⅛ inch square test piece. If the stopper is placed slightly out of position the error is much less than with the regular type. An operator can average 15 determinations per hour for a day's run.

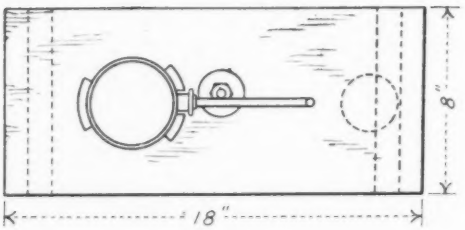
To operate the volumeter the displacement liquid is run into the container "A" until it runs up into the cap "C" to the zero line. There must be sufficient liquid to run up into the burette to the zero line. If it runs up higher it can be drained out into the beaker.

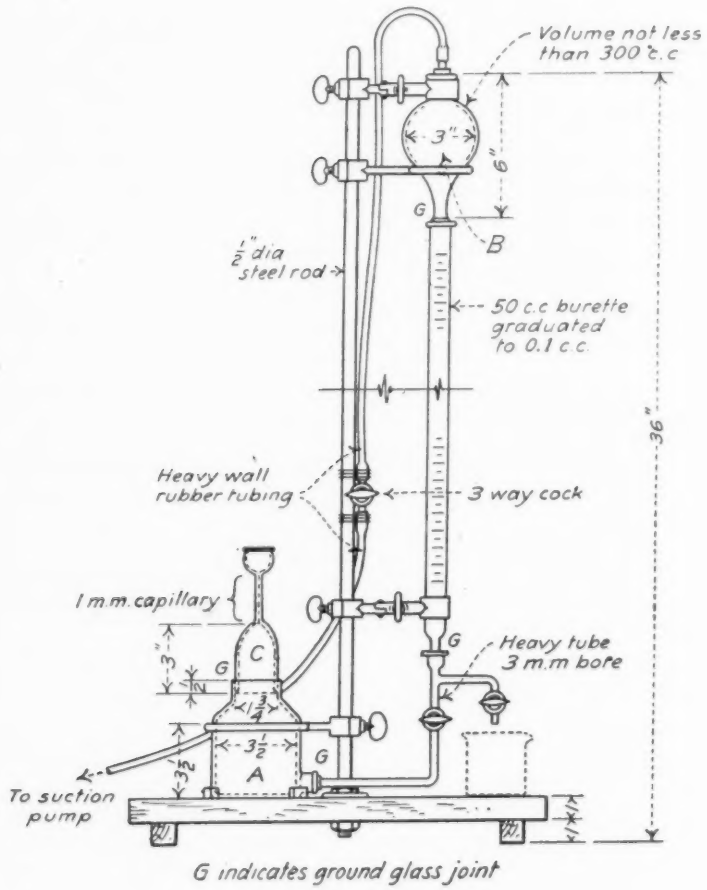
Raising and lowering of the liquid is controlled by means of a suction from the bulb "B" generated by a filter pump. When the instrument is filled it is left at rest one minute to allow the sides of the burette and container "B" to thoroughly drain. The liquid is then drawn up into the burette and bulb "B" far enough to allow room in the container "A" to remove the cap and place the saturated test piece into it. The cap is then replaced and the liquid run back into the container until it runs up to zero on the cap. The liquid is then allowed to drain down the sides of the burette for half a minute and the reading made. The volume of the test piece will be the difference in readings of the burette before and after placing the test piece in the container.

A very satisfactory volumeter of the pycnometer type is described by Schurecht. [1] The author states that the volumes on 30 to 60 test pieces can be made per hour.

Operation. The bottle is filled with liquid and, as the stopper is inserted, sufficient liquid is forced into the tube in the stopper so as to fill it completely. The excess liquid is carefully wiped off and the bottle is weighed. The briquette to be measured is then inserted into the bottle and the operation is repeated. The calculation involved is as follows:

[1] Jour. A. C. S. Vol. I, No. 8, Aug. 1918, Page 556.





After B. of S., Pgh. Pa

Fig. 14

$$V = \frac{W - Wb + B}{S}$$

V = volume
W = weight of bottle plus liquid
Wb = weight of bottle plus liquid plus briquette
B = weight of saturated briquette
S = specific gravity of the briquette

It is necessary to check the weight of the bottle plus the liquid at intervals as minute particles of clay, dropping from the briquettes, may increase the weight. Also on account of the effect of temperature changes upon the oil, if used. This method requires the weighing of the entire apparatus. It also necessitates the determination of the saturated weight. This is difficult to determine accurately on account of enclosed pore spaces and hence does not have the same accuracy as a method where volume is all that is considered.

Another volumeter adapted to clay testing is described by Shaw[2] and is similar in operation to the Hubbard and Jackson apparent specific gravity apparatus. The previously saturated and weighed test piece is placed in a vessel of known volume. The vessel is then filled with whatever liquid is being used. This liquid is supplied from a calibrated burette and the amount required is read directly from the burette. The volume of the test piece then is the difference between the volume of the container and the volume of the liquid used to fill the container after the test piece is placed in it. The greatest chance for error with this instrument is the necessity of removing the liquid from the vessel to the same degree each time, hence it should be drained a definite time between each measurement.

Fig. 15 illustrates a volumeter similar in operation to the Goldbeck apparent specific gravity apparatus but arranged by Staley with a direct reading tube and scale, placed at such an angle that a small rise in level is magnified to the proper degree for accuracy.

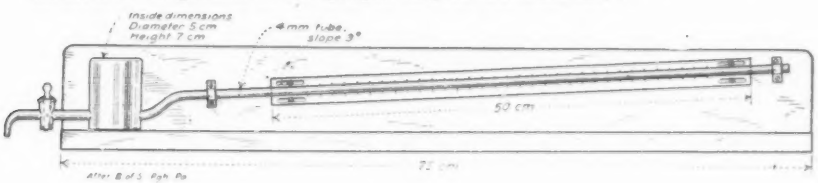


Fig. 15

This apparatus is operated very easily and rapidly, it being only necessary to read the scale before and after immersing the test piece. It is absolutely necessary, however, that the angle of the tube be kept

[2] Jour. A. C. S. Vol. 2, Page 481.

the same. This requires considerable care and should be checked at intervals with a standard test piece of known volume.

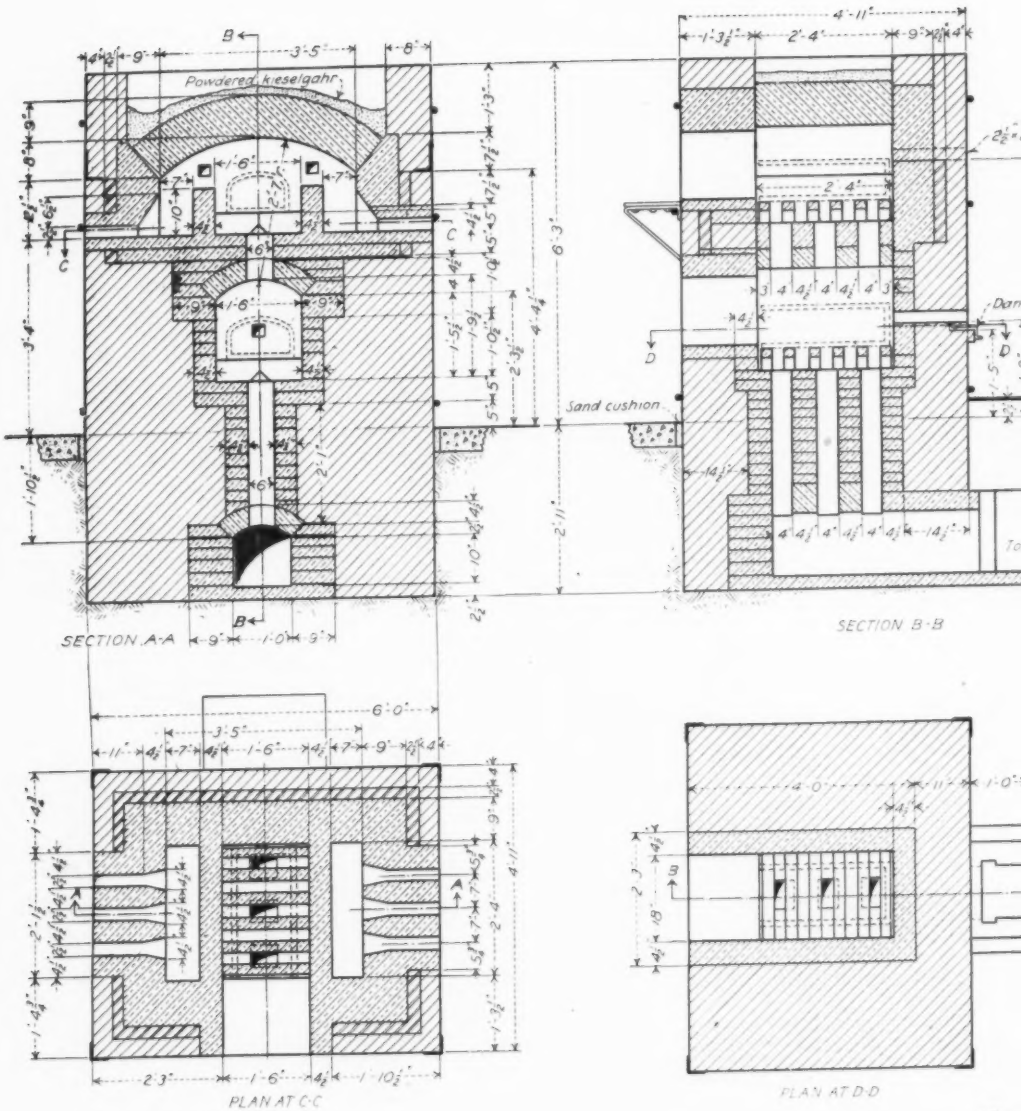
The operation of the Goldbeck apparatus from which the above instrument is designed is simple. The container is filled with liquid until level full. The test piece is then put in, the overflowing liquid being caught in a burette. The amount overflowing is, of course, equal in volume to the test piece. This instrument is more difficult to keep level than the Staley and not read as rapidly. However, it is the simplest volumeter of all and sufficiently accurate for ordinary work if reasonable care is used. It is not recommended by the Society for regular laboratories and should be used only in special cases.

A mercury volumeter, simple and quick in operation, is described in Vol. 4 Jour. Am. Cer. Soc. 1921 page 288. This was designed by the Bureau of Mines and is recommended as a reliable instrument.

4. Tabulation of Data

The following method of ruling paper is a convenient form to use in tabulating results, including those determined after burning.

Specimen No.	Wet Wgt.	Dry Wgt.	% W't'r	Dry Vol.	% Vol. Dry Shr'k	Burn Vol.	Burned DW	Burned WW	% Porosity	% Vol. Burn Shr.	T'mp of Dr'w	Cone Fus'n at Dr'w
1												
2												
3												
4												
5												
6												
7												



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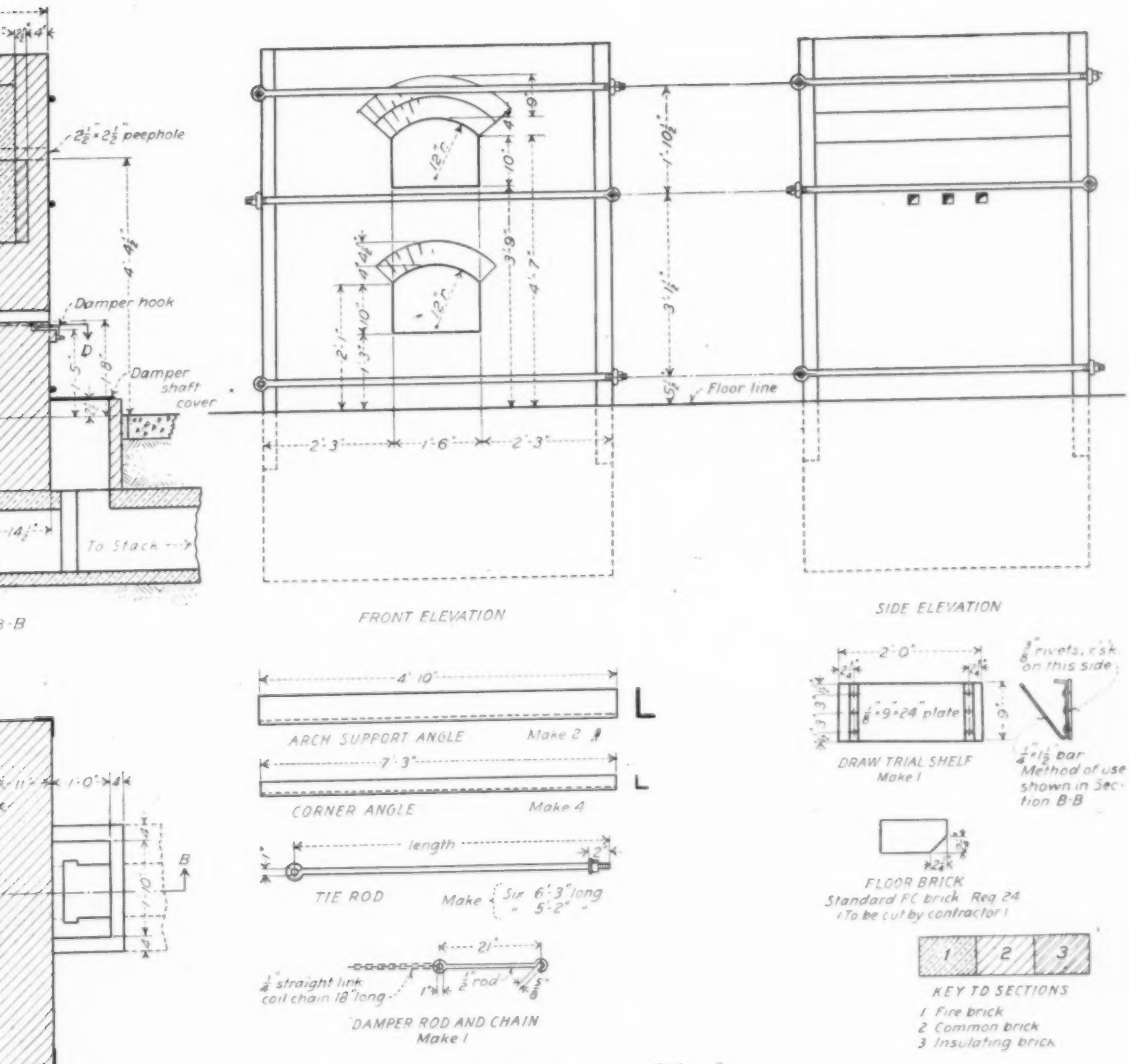
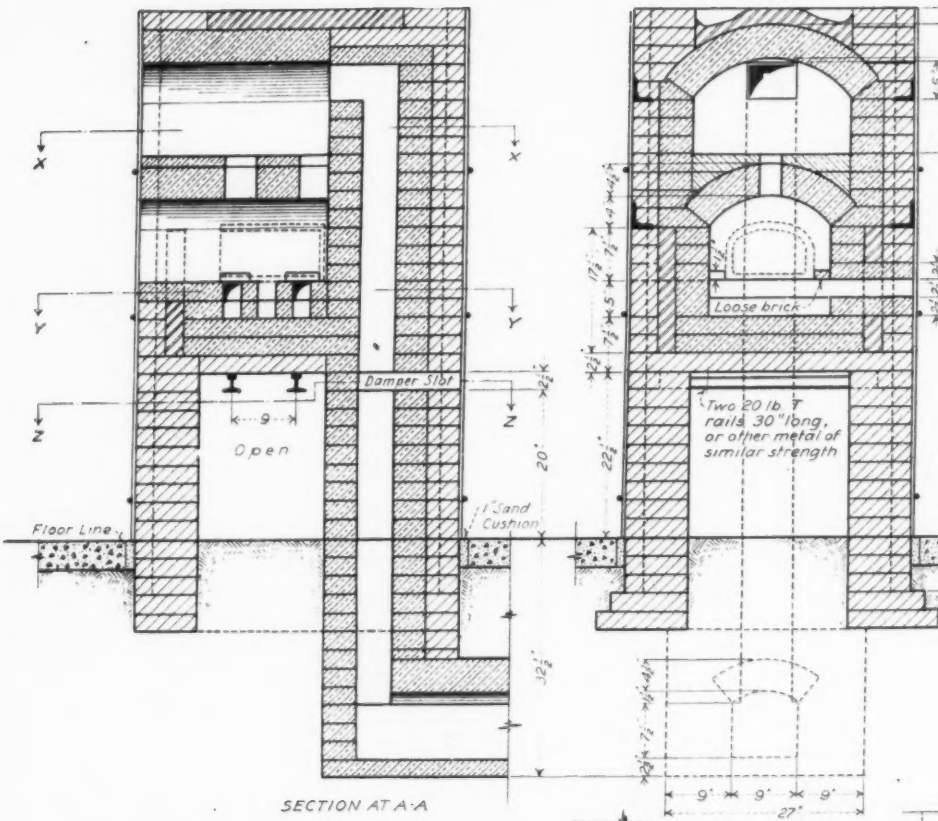
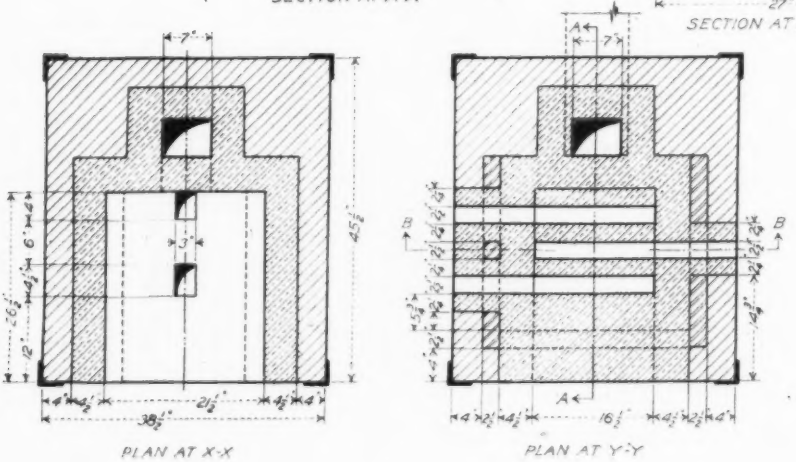


Note. This kiln is designed for muffle 13½"×9"×26½" outside

Fig. 16

ns by Bureau of Standards)





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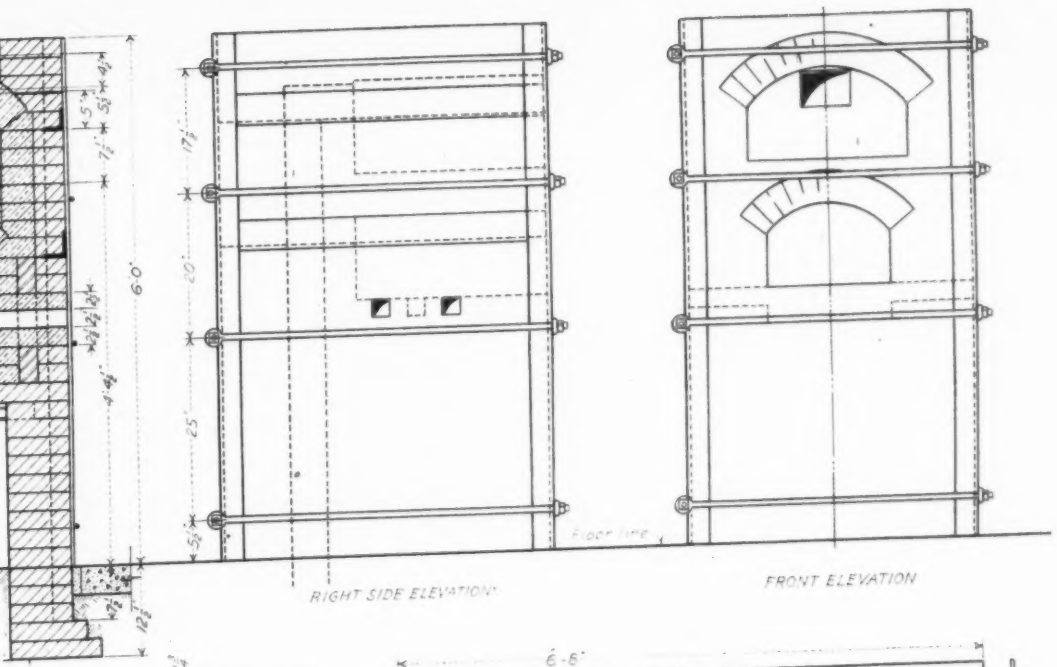
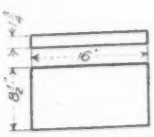
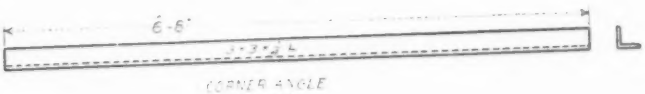
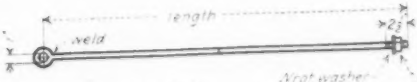
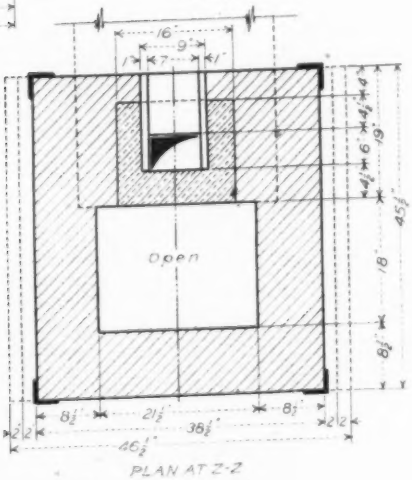
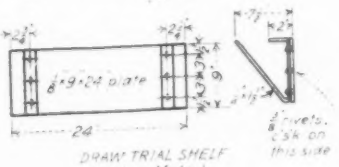


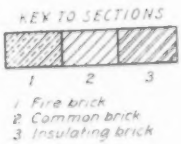








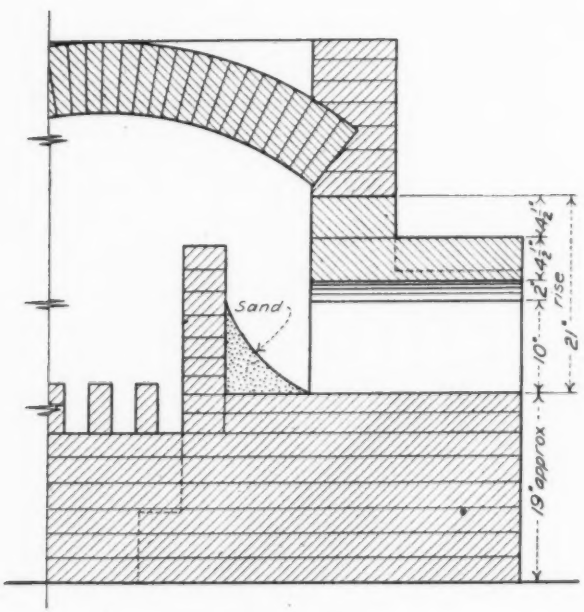




Note This kiln is designed for muffle 12"×8"×5" outside

Fig. 17

gns by Bureau of Standards)



SECTION AT B-B

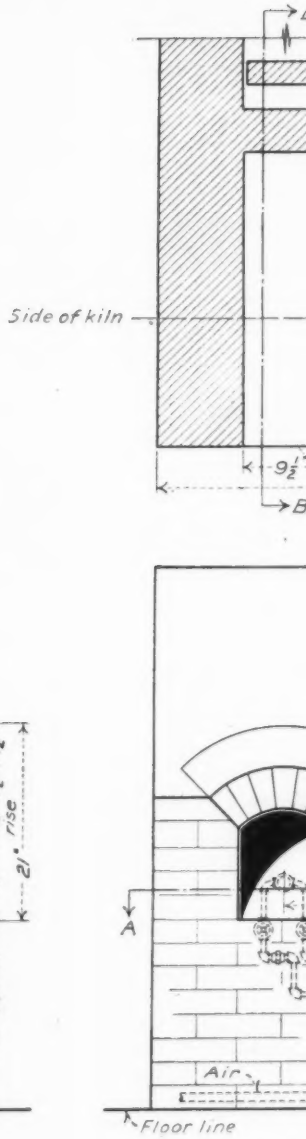
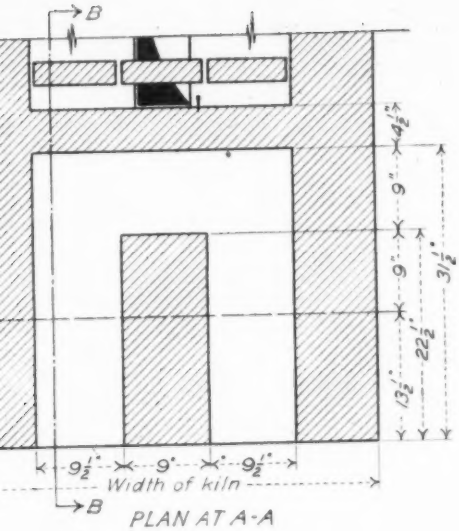
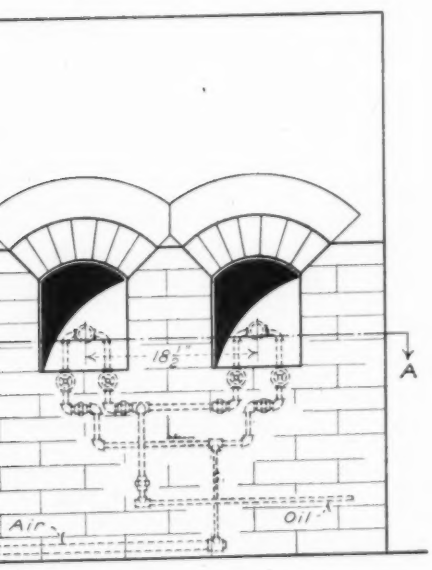


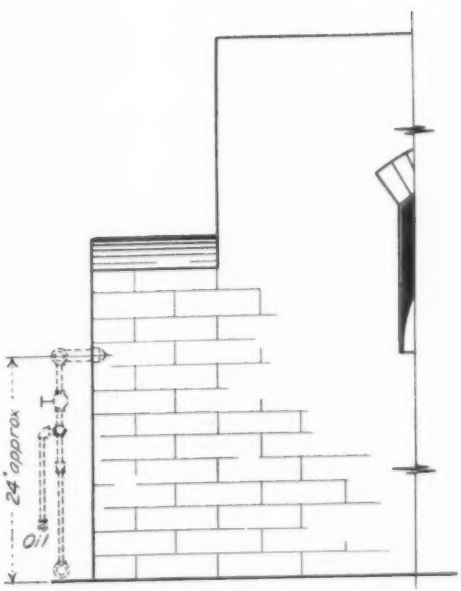
Fig. 15
(From designs by Bureau



PLAN AT A-A

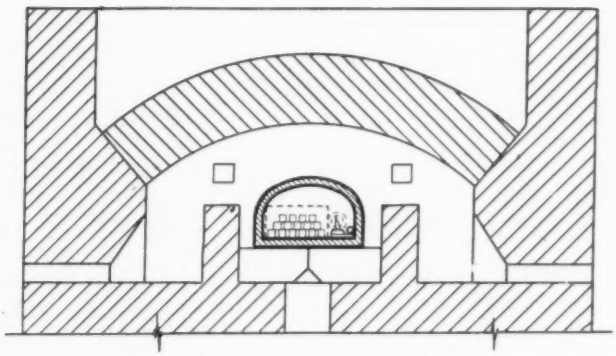


SIDE VIEW



FRONT VIEW

Fig. 1B
by Bureau of Standards)



Location of Muffle in the Kiln

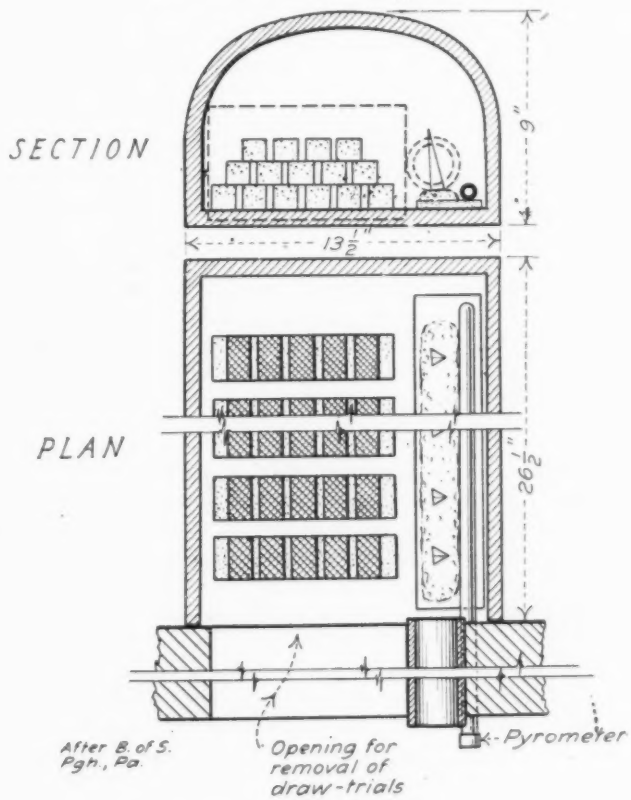


Fig. 19

5. Method for Behavior in Firing

Figures 16 and 17 illustrate two types of kilns for use in making draw trial burns. Any small kilns in which muffles can be placed are satisfactory but they do not have the advantage of the annealing muffle, height for the convenient drawing of trials, etc. The kilns shown are designed for gas and air. To burn oil, it would require additional oil box space as shown in Figure 18 while coal would require considerable alteration, not only of fire boxes but also flue openings.

Figure 19 illustrates a suitable arrangement of cones, test pieces and pyrometer in the muffle. This, of course, can be varied somewhat so long as the cones and test pieces to be drawn at the softening point of the cones are close together. The figure shows a cone directly in line with each group of test pieces. The test pieces in each group are drawn at the softening of the cone in line with them. The hot junction of the thermocouple can also be very close to this point if the couple is drawn out of the kiln until the hot end is opposite the trials to be drawn and pushed into the klin as required. The illustration shows 15 different stacks of test pieces arranged for drawing. In work of this sort care should be taken in knowing something about the range of each body or clay before placing the kiln as it is possible to have one test piece overburn and soften or even melt and spoil several others in the same group.

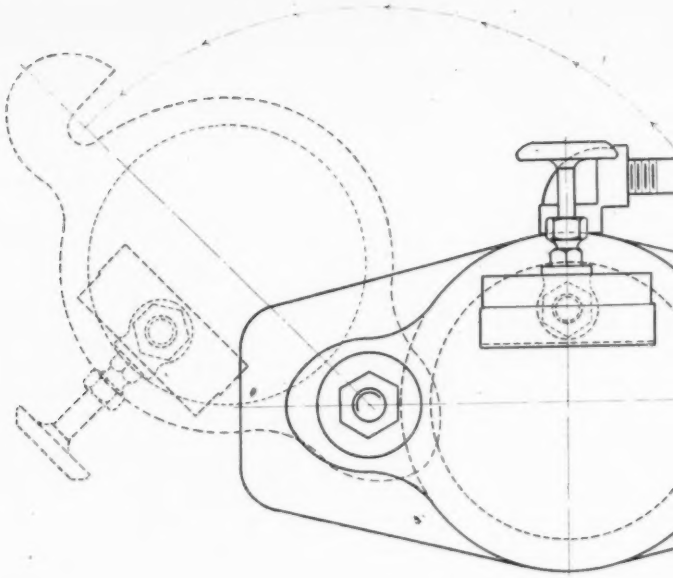
If the test pieces are properly marked in sequence for each laboratory number they should be placed in the muffle with No. 1 piece for the first draw, No. 2 for second, etc. This makes it easy to sort the pieces as well as to avoid hopeless mixing in placing the pieces in the annealing muffle, unless undue care is exercised in drawing and placing in the annealing muffle.

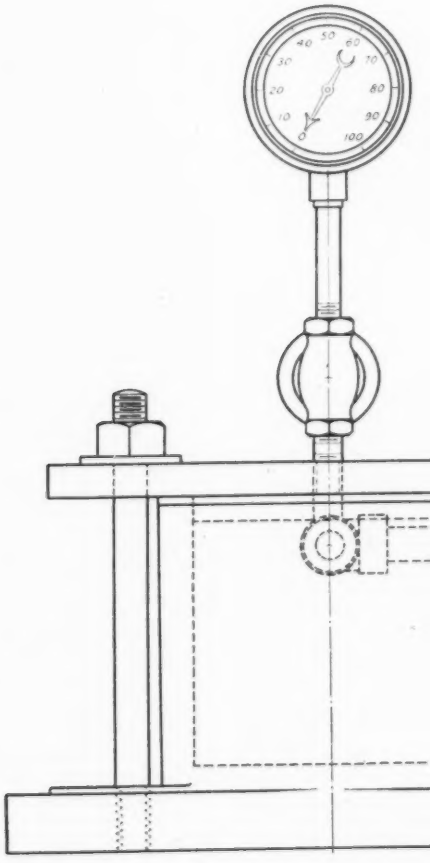
6. Apparent Porosity

More refined methods than the standard are sometimes desirable, as in the case of vitrified porcelains for electrical purposes.

A liquid that penetrates easily should be used for determinations of this sort and it should be colored with some organic color so that the distance of penetration of the liquid into the body can be noted. Ordinary methods of boiling or immersing are not sufficiently severe and pressure has to be used.

The most satisfactory method is to have a strong iron container arranged with a properly bolted cover (Fig. 20). Place the test piece in the container, fill it to overflowing with the colored alcohol so no air will be left in, and then continue to fill the tank by means of a small piston plunger pump properly connected to the container with a valve between. The unit of measure will be the pressure applied.




40
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60
70
30
80
20
90
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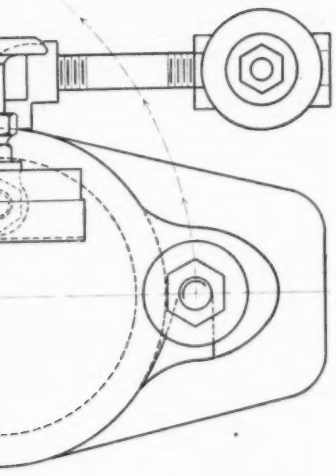
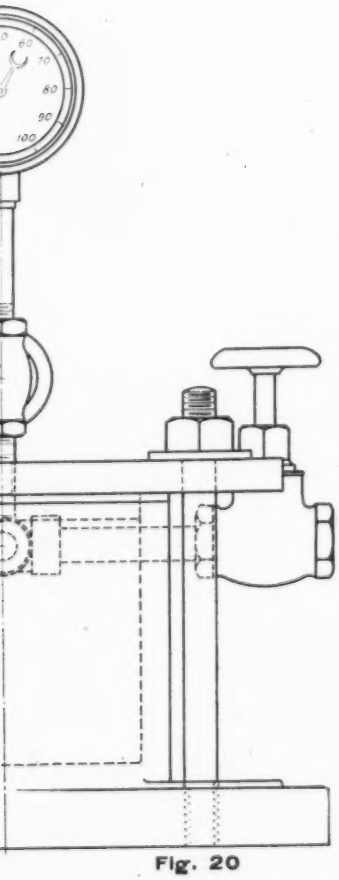
100
0





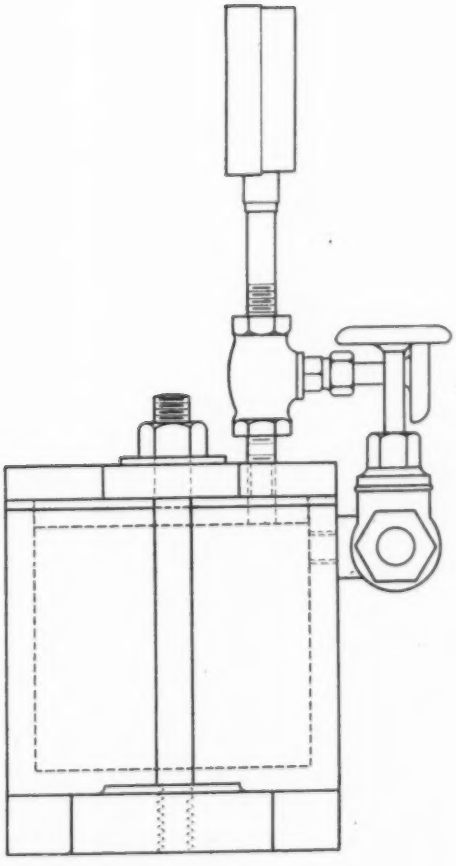


Fig. 20

For example, it may be found that for certain purposes it is necessary that there should be no penetration of the alcohol into the porcelain when held at 50 pounds pressure for 15 minutes. It would simply be necessary then to place the test piece in the container, apply the pressure, hold it the necessary time, release, remove the test piece and break it to see if there has been a penetration. A pressure of at least 80 pounds should be available for this work.

In the standard method for apparent porosity, the test pieces after being saturated by boiling may be cooled by running cold tap water into the pan containing them. Care should be taken, however, to see that the test pieces are continually covered with water.

The results should be tabulated in the amount of penetration rather than weight of the liquid absorbed. (See also Tentative methods for Testing Electrical Porcelain, article 28 p 10-46 and following.)

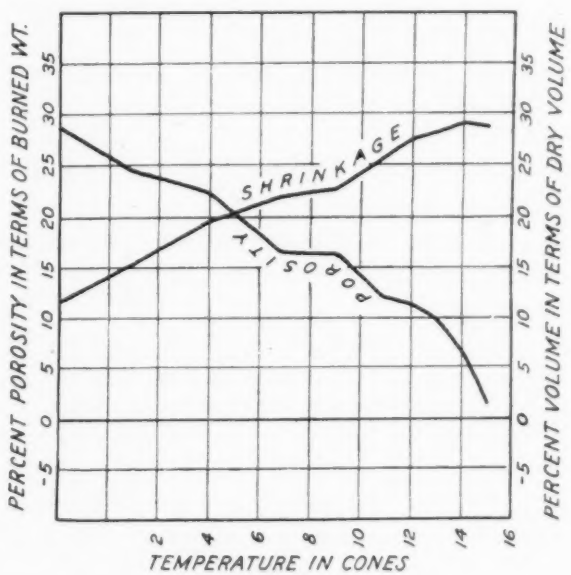


Fig. 21

7. Apparent Specific Gravity

Apparent specific gravity is the specific gravity of the water impermeable portion of the specimen, that is, solid material plus sealed pores or cavities. Apparent specific gravity is then the weight per unit of volume of water impermeable portion of the specimen.

8. Bulk Specific Gravity.

Bulk specific gravity is the specific gravity of the composite bulk, that is, solid material plus sealed pores or cavities, and water permeable pores. Bulk specific gravity is therefore the weight per unit of exterior volume.

9. True Specific Gravity

True specific gravity is the weight per volume of the solid material in which all sealed pores or cavities and all water permeable pores have been obliterated by fine grinding.

10. Plotting Results

Figure 21 shows a suitable method of plotting results of a draw trial burn. Note that the temperature in degrees C is given under the cone number. Both the Porosity and Volume changes are plotted on the same chart, as it makes a convenient means of comparing the results.

11. Methods for Water of Plasticity

The same test pieces that are used for burning can be used for determining the water of plasticity. Only three of the pieces require the wet weights and volumes.

This also applies to Shrinkage and Pore Water test pieces.

12. Method for Softening Point

If desired, a hardened steel crusher and rolls may be used for reducing the specimen to be tested, to the required fineness.

13. Record of Tests

It is important that a form be arranged upon which the results of each clay test can be conveniently recorded. Below is a copy of the form used at the Bureau of Mines Station, Seattle, Washington, which will be of assistance to others in arranging forms for their own laboratories.

ORIGINAL PROPERTIES

Location	Number
Dry Color	Hardness
Visible Objectionable Materials	Notes
Mechanical Analysis	

PLASTIC AND DRY PROPERTIES

Color Wet	General Plasticity
% Shrinkage Water	% Dry Volume Shrinkage Per cent Dry Volume
% Pore Water	
% Water Plasticity	Calculated Linear Sh. Per cent Dry Length
	Measured Linear Sh. Per cent Plastic Strength
Dry Transverse Strength	Pounds per sq. in.
Dry Condition and Notes	

FIRED PROPERTIES

Cone								
Color								
Hardness								
Linear Shrinkage, per cent plastic length								
Calculated Linear Shrinkage, per cent dry length								
Volume Shrinkage, per cent dry volume								
Per cent Absorption								
Per cent Apparent Porosity								
Transverse Strength, pounds per sq. in.								
Structure Condition								
Best Firing Range Class of Ware	Cone Fusing							

14. Tentative Method for Transverse Strength

Among the many articles on this subject, the following may be cited as representative and giving data indicative of the results this method of test can be expected to yield.

Kerr and Montgomery, Trans A.C.S. Vol. 15; 271
Vol. 15; 345

Bleininger and Howat, Trans A.C.S. Vol. 16; 277

Kerr, Montgomery and Fulton, Trans A.C.S. Vol. 17; 92, 95, 97

REPORT OF THE COMMITTEE ON RESEARCH AND DEVELOPMENT

On March 14, 1921, the undersigned was notified of his appointment as Chairman of the Research and Development Committee of the American Ceramic Society. The first activity of the Chairman was to communicate with the former chairmen of this committee, in order to ascertain what had been accomplished by this committee in the past. It was found that, due to lack of knowledge as to exactly how to proceed, very little had been accomplished. The members of the committee were, therefore, communicated with in order to get their views as to how the committee might best proceed to organize and operate, and many valuable suggestions were received. These were communicated to all members of the committee, as then constituted, for further suggestions. Later, it was found that the committee, as made up, was not in accordance with the rules of the Society, and a new committee was appointed, consisting in the main, however, of the members of the committee as first appointed. Other requests for suggestions as to operation were sent out, and further recommendations received.

After considering these suggestions, it was decided to hold a meeting of as many members of the committee as could conveniently come to Columbus on November 16 and 17. At these meetings, at which were present a part of the membership of the committee, as well as the President of the Society, the Organizing Secretary, and several interested visitors, a set of 13 recommendations were drawn up, approved by those present, and sent to all of the members of the commmittee for their vote, as to approving or disapproving, and to the members of the Board and officers of the divisions for their information.

After a delay of two months votes had been received from all members of the committee, except two, the results of this voting being that all of the recommendations were approved by more than a majority of the committee. In these recommendations was given a general outline of the method of operation of this committee, which is as follows:

That the Chairman request from each divisional member of the committee a list of research problems arising in the work of that division, with their relative importance, suggestions as to where the problem might be undertaken, estimated money required in the solution of the problem, if any, recommendations as to where and how this money might be raised, and reasons why each problem is of

importance. It was the thought of the meeting that the method of obtaining such a list of problems should rest with the divisional member of the committee, but that some method should be used which would insure a fairly reasonable completeness of such a list consistent with the time available for getting up such a list.

That the list of problems received from the different divisional members then be reviewed by each member of the committee, they giving criticisms and suggestions on the problems listed, making additions thereto if possible, giving their recommendations as to the most important problems out of all the lists to be undertaken, and recommendations as to where and how the problems might be taken up. It was the thought of the meeting that it would be attempted to take up the second step by correspondence, but if it was found that results could not be obtained by this procedure, that a meeting of the committee would then be called to undertake the work in conference.

That the list of problems, together with the recommendations of the committee, be then printed in the bi-weekly bulletin issued from the Secretary's office, together with the request that anyone who might be willing to undertake one of these problems communicate with the chairman of the committee, stating under what conditions he could undertake it, and the plan of attack; and further asking anyone who hears of any work having been done on any one of these problems to communicate with the chairman, giving data as to where it was done, whether complete or not, and whether published or not. Reprints of the list of problems, with recommendations of the committee, to be also sent to all Federal bureaus, university departmental laboratories, and industrial laboratories, where it is thought work might be undertaken on any one of the problems, with the request that anyone who is willing to undertake one of the problems communicate with the chairman, stating under what conditions he could undertake it and the plan of attack. It is contemplated, in addition to publishing the lists in the bi-weekly bulletin from the Secretary's office, to at least get notices and if possible the full list published in other technical journals of the ceramic and allied fields, and bring the attention of scientific societies in allied fields to the work of this committee and the desirability of co-operaton at the general meeting.

That the data as to where and how the problems might be undertaken, as received from the laboratories and in answer to the published announcement, be then referred to each member of the committee for recommendations as to where and how they be taken up, and the problems then assigned; the divisional member of this committee in whose divisional field it comes, to be notified to keep in touch with the problem as closely as possible through the Secre-

tary's office, at least demanding semi-annual reports on July 1 and January 1 from the laboratory undertaking the problem, such reports to be submitted after criticism by the divisional member to the total membership of the committee through the Chairman.

That in case no reply is received to communications to members of this committee two weeks after sending such communications, it be considered that the member did not desire to make such a reply, except in the case of request for lists of problems, which lists should be expected not later than six weeks after date of request.

That the method of raising funds and procuring materials should be, as agreed upon by the Divisional Research Committee and the general committee, but that the responsibility for raising of such funds or procuring of materials rests on the Divisional Research Committees.

That it be the policy of this committee to not take up, as a committee or as individual members of the committee, with any group or agency carrying on research, the possibility of our supplying to such agency a committee to work with them. It was, however, agreed that it would be allowable for any individual, as such, to suggest to any agency conducting research the possibility of their having an advisory committee appointed. It was also agreed that general notice should be given by means of announcements from this committee, in trade papers, etc., that the committee stood ready and willing to assist in any way possible anyone undertaking ceramic research.

The other recommendations adopted deal with matters which cannot be decided by this committee without reference to other committees, etc., and, therefore, will not be incorporated in the report of this committee until after such reference.

It is realized this method of procedure is not ideal, but it is hoped that as time goes on it will be improved so as to make for the best working conditions for this committee. Recommendations as to changes will be gratefully received from anyone.

Respectfully submitted,

L. I. SHAW, Chairman.

Columbus, Ohio, January 27, 1922.

Property of
Research Division

REPORT OF THE JOINT COMMITTEE OF THE NATIONAL RESEARCH COUNCIL AND THE AMERICAN CERAMIC SOCIETY

The committee held no meetings during the past year principally for two reasons, the depressed industrial conditions and the reorganization work of the American Ceramic Society. Some confusion existed in regard to the position of this committee to the general activities of the Society and it is still a question as to whether its functions should not be taken over by another committee entirely within the Society. The Research Council in its broad endeavor to promote scientific and technical investigation, we are quite certain, would offer no objection to the discontinuance of this committee provided its place were taken by another body having similar aims.

The work of the fellowship on the viscosity of glass supported by the Corning Glass Works is making good progress and the results obtained will be made available through publication in the Journal.

The co-operative research on the kilns and the methods of firing in the heavy clay products industries which was started under the auspices of this committee has been turned over entirely to the Bureau of Mines, the Bureau of Standards and the Heavy Clay Products Division of the Society, functioning through a joint technical committee. This investigation is supported by four associations, the Common Brick Manufacturers' Association, the Hollow Building Tile Association, the Face Brick Association and the National Paving Brick Manufacturers' Association, and by larger funds appropriated by the Bureau of Mines and the Bureau of Standards. This study consists of field and laboratory work carried on by the Federal Bureaus and the Department of Ceramic Engineering of the University of Illinois. The Fuel Division and the Columbus Station of the Bureau of Mines have organized the field work in a very thorough manner and have now in operation a laboratory car which is dispatched to the different plants. Complete heat balances of a number of kilns have been worked out and have already lead to improved firing methods. The laboratory studies on the problems relating to the rate of water-smoking, oxidation, the speed of vitrification and the heat absorption of clay are fully under way and a number of interesting results have been obtained.

It is to be hoped that the Society at its next meeting will define the functions of this committee or transfer its duties to another group.

Respectfully submitted,

A. V. BLEININGER, Chairman.

REPORT OF COMMITTEE ON RULES, 1922

Following our report at the last annual convention, the Rules Committee completed the revision of the Constitution and By-Laws and submitted same to the Board of Trustees.

On September 15, the Committee reported favorably on the amendments to Articles II and III of the Constitution, covering the creation of Industrial Association Membership.

On October 8, the Committee reported favorably on the amendments to Article VI, made necessary by the reorganization of the Research and Development Committee, and the creation of the Co-ordinating Service Council.

On Janary 17, 1922, the Committee reported favorably on the amendment to Article VI, paragraph 7, interpreting the method of counting votes on standards.

On January 21, 1922, the Committee reported favorably on the recommendation of the Executive Conference covering the establishment of a Committee on Ceramic Education.

On recommendation of R. R. Hice and by instruction of President F. K. Pence, the Chairman of the Rules Committee secured legal advice as to whether the Society, in engaging in the various activities now contemplated, is exceeding the authority conferred upon it by the Charter granted it by the State of Ohio. The opinion rendered is appended in full.

Respectfully submitted,

ARTHUR S. WATTS, Chairman,
R. L. CLARE,
R. K. HURSH,
T. A. KLINEFELTER,
J. B. SHAW,
Rules Committee.

LEGAL OPINION REGARDING LEGALITY OF PRESENT ACTIVITIES

Gentlemen:

Question::—Do the Constitution and By-Laws of the American Ceramic Society exceed the authority conferred upon the American Ceramic Society by the State of Ohio?

The powers of a corporation in Ohio are those expressly conferred upon it by the State in the Charter, and reasonably proper in carrying the express powers into execution. Gas Co. v. Dairy Co. 60-O.S.-96. The implied power to do what is necessary to effect granted powers must be construed reasonably rather than with a strictness that would embarrass the business and include not merely what is indispensable, but also what is appropriate, convenient and suitable, including a reasonable choice of means to be employed. Gas Co. v. Dairy Co. 60-O.S.-96, Longsdorfs Notes 778, cited in 70 American State Reports 161, 179, followed in State vs. P. C. C. & St. L. R. R. 68-O.S.-40, holding that maintenance of a relief association by a railway company for the benefit of the employees injured is not ultra vires.

William Lawrence Clark, the best known recent authority on corporation law, states that a charter of a corporation is a contract between the State and corporation, and the corporation and its members That the constitution and by-laws of a corporation merely effect the management of its business and control its officers and agents. They constitute no part of its charter and, therefore, can neither add nor detract from the charter.

The foregoing paragraphs have been set forth as principles of law involved in the question stated. The reason for the following opinion, it is hoped, will be more easily understood by keeping these principles in mind.

The charter of the American Ceramic Society, filed with the Secretary of State on the 25th day of March, 1905, contains the following purpose clause: "The purpose for which said corporation is founded is to promote the arts and sciences connected with ceramics by means of meetings for social intercourse, for the reading and discussion of professional papers and for the publication of professional literature."

It is quite evident that the purpose clause in the charter, which is the power conferred by the State on the Society, is not as broad in scope as the purpose expressed in Article 1, Section 2, of the Constitution and By-laws of the Society. It is also evident that the author of the purpose clause in the charter could have greatly enlarged the express powers of the Society and thereby its incidental powers, by a

clear statement of the purpose with the usual added phrase, "and doing all things necessary and incident thereto."

To amend the purpose clause now would entail an enormous amount of time and considerable expense. I have, therefore, made a thorough search of the law to determine whether or not the State could complain of the exercise of the work of the Society as detailed in the constitution and by-laws or whether the members of the Society could complain.

From all the reported cases on this subject in Ohio and other States, and from the leading texts and opinions of authors of texts, I have come to the following conclusion:

1. As the constitution and by-laws stand now, neither the State nor the members of the Society could be heard to complain in law. Late decisions particularly have been more liberal and broad in the construction of vested and implied powers. There are no cases directly in point, but all analogus cases have sustained this view.

2. The constituton and by-laws of the Society may be safely amended from time to time to enlarge the scope of work undertaken by the Society in its endeavor to promote the arts and sciences of ceramics, conduct its own laboratories, supervise control, or directly publish its own literature, and do all things necessary and incident thereto, as long as its efforts are purely **not for profit** in the commercial sense. It may own real or personal property, sell and exchange such property from time to time, as long as such property is devoted exclusively to the advancement of the arts and sciences of ceramics. For instance, the Society could purchase a business building for laboratories, print shop, office and assembly hall, restaurant and recreation quarters for workmen. It could hire all laborers and professional men necessary to conduct its business. It could not rent space and take a rental, for that would substantially transgress on the scope of operations of realty companies. It could not finance or financially aid outsiders in putting any device or ceramic product on the market. It could not operate its restaurant or creation department at any more than actual costs to the Society. As organized, it is a single unit, engaged in a special work. The State will allow the Society to realize its aim by choosing its own means or ways on a small scale or large scale as it chooses, as long as the operations are not for profit, and directed to the promotion of the arts and sciences of ceramics by means of meetings. It is allowed to do all things necessary and incident to the production of material for the publication of professional papers and literature. If actual experiments and investigations are the necessary agencies necessary to produce such results then, and in such event, the law permits the operation under the implied powers of the original grant or charter.

I am, therefore, of the opinion that the constitution and by-laws as they now stand do not exceed the granted and implied powers of the American Ceramic Society.

Respectfully submitted,
JOHN F. SEIDEL.

STATE OF OHIO
These Articles of Incorporation of
AMERICAN CERAMIC SOCIETY

Witnesseth, That we, the undersigned, a majority of whom are citizens of the State of Ohio, desiring to form a corporation, not for profit, under the general corporation laws of said State, do hereby certify:

First, The name of said corporation shall be

The American Ceramic Society

Second, Said corporation shall be located, and its principal business transacted at Columbus, in Franklin County, Ohio.

Third, The purpose for which said corporation is formed is to promote the arts and sciences connected with Ceramics by means of meetings for social intercourse, for the reading and discussion of professional papers and for the publication of professional literature.

IN WITNESS WHEREOF, We have hereunto set our hands this 21st day of March, A. D. 1905.

WM. D. GATES,
ELLIS LOVEJOY,
EDWARD ORTON, JR.,
STANLEY G. BURT,
ELMER E. GORTON,
EDWARD C. STOVER,
A. V. BLEININGER,
WALTER M. FICKES,
W. D. RICHARDSON.

The State of Ohio, County of Franklin, S. S.

On this 21st day of March, A. D. 1905, personally appeared before me, the undersigned, a Notary Public, within and for said county, the above named Walter M. Fickes, Wm. D. Gates, Edward Orton, Jr., Elmer E. Gorton, A. V. Bleininger, Ellis Lovejoy, Stanley G. Burt, Edward C. Stover, W. D. Richardson, who each severally acknowledged the signing of the foregoing articles of incorporation to be his free act and deed, for the uses and purposes therein mentioned.

Witness my hand and official seal on the day and year last aforesaid.

(Seal)

H. E. STAFFORD,
Notary Public.

The State of Ohio, County of Franklin, S. S.

I, John W. McCafferty, Clerk of the Court of Common Pleas, within and for the county aforesaid, do hereby certify that H. E. Stafford, whose name is subscribed to the foregoing acknowledgment as a Notary Public, was at the date thereof a Notary Public in and for said county, duly commissioned and qualified, and authorized as such to take said acknowledgment, and further, that I am well acquainted with his handwriting and believe that the signature to said acknowledgment is genuine.

In Witness Whereof, I have hereunto set my hand and affixed the seal of said court, at Columbus, Ohio, this 22nd day of March, A. D. 1905.

(Seal) JOHN W. McCAFFERTY, Clerk.

United States of America, State of Ohio, Office of the Secretary of State, ss:

I, Lewis C. Laylin, Secretary of State of the State of Ohio, do hereby certify that the foregoing is an exemplified copy, carefully compared by me with the original record now in my official custody as Secretary of State, and found to be true and correct, of the Articles of Incorporation of The American Ceramic Society filed in this office on the 25th day of March, A. D. 1905, and recorded in Volume 102, page 526, of the Records of Incorporation.

In Testimony Whereof, I have hereunto subscribed my name and affixed my official seal at Columbus, the 25th day of March, A. D. 1905.

LEWIS C. LAYLIN,
Secretary of State.

(The Seal of the State of Ohio.)

REPORT OF THE COMMITTEE ON PUBLICATIONS AMERICAN CERAMIC SOCIETY

The publication of the Journal during the past year has been more difficult than in any previous year on account of the printers' strike last April. At that time the Journal was beginning to make its appearance on time, but the strike threw it back several weeks. This difficulty has now been overcome and it is expected that the Journal will appear regularly during 1922.

The publishing of the technical Journal involves considerable detailed work and constant decision on the problems that arise. The Committee on Publications has considered and passed upon many matters tending to improve the Journal and make it of more service to subscribers. Some decisions that are of general interest are:

1st. Readoption of the rule allowing reprints to authors.

2nd. Arranging for exchange of advertisements with the English Journal of Glass Technology.

3rd. That as a matter of policy editorials should not take the form of personal letters.

4th. Changing title of Journal to "Journal of American Ceramic Society Together With Ceramic Abstracts." Each section will take separate pagination.

5th. Insertion of advertising page at front of Journal, taking preferred rates.

6th. Limiting of reading matter to approximately 85 pages.

7th. Change in color of Journal cover. It is believed this improvement will meet with general approval.

The advanced advertising rates made it necessary to renew all advertising contracts. This was done with the loss of only one old advertiser. In 1920 there were 142½ pages of advertising in the Journal. In 1921 the advertisements amounted to 200 pages, including the December issue. In addition there were eight pages in the Year Book which had never before carried advertising.

The financial statement for the year is as follows:

Receipts		Disbursements	
Advertisements	$ 7,682.15	Salaries	$2,892.15
Volume of Trans. sold	1,145.73	Editor's Office Expense	322.26
Journal Subscriptions	1,695.07	Printing of the Journal	10,632.01
Index, Seger, etc.	407.57	Reprints	607.25
Reprints	356.09	Advertising Commissions	969.61
		Other Expenses	380.86
	$11,286.61		$15,804.14

Although receipts exceeded 1920 by nearly $4,000, the expenses increased equally. Therefore the Journal cost the Society actually $4,517.53 for the year.

It is generally conceded that the Journal is our most important agency in increasing the service of the Society to its membership. This committee plans to make the Journal of 1922 of greater value than ever before.

The Chairman desires to take this opportunity of expressing his appreciation of the splendid support of the Editor, the efficient work and many helpful suggestions of the Advertising Manager and the prompt and friendly co-operation of every member of the committee.

Respectfully submitted,

(Signed) R. H. MINTON,

Chairman, Committee on Publications.

REPORT OF THE EDITOR FOR THE YEAR 1921

Delays in Publication

Several causes during the current year have been responsible for the numerous delays and difficulties in connection with the regularity of publication. The protracted strike in the printing office caused the Journal to fall three months behind schedule. Toward the latter part of the year when attempting to recover lost ground and bring the publication of the Journal up to date, the extra work proved too great for the editorial staff to handle promptly since the Editor's office force is not of sufficient size to see three issues through the press in one month. It was necessary therefore to procure some additional assistance to help with the indexing.

Changes in Editorial Staff

In September a motion was made in the Board of Trustees that the duty of editing the Journal during 1922 be placed in the hands of the Secretary of the Society. After a protracted discussion the motion was lost, but it resulted in the resignation of the Editor's assistant toward the latter part of November owing to the impossibility of assuring her of any employment after January 1. For a period of two weeks the Editor was without any assistance and thereafter a further period was necessary for the new assistant to familiarize herself with the records of the office and the many and complete details of the work.

All of these factors have contributed to the difficulties of maintaining the standard desired in the Journal and it is hoped that in the future actions looking toward changes in the personnel of the Society's editors may be taken sufficiently in advance of the proposed date of execution to avoid the disruption of the editorial office machinery. To the same end it is recommended that the Editor be authorized to contract with his assistants for a definite time with the usual provisions on both sides regarding notce of resignation and penalties for breach of contract.

Publication Policies

The inauguration of the new Bulletin to be published from the Secretary's office brings up a variety of new problems in connection with the Society's publication activities which must be settled. The relations of the two publications to each other and to the Publication Committee should be clearly defined. In the opinion of the Editor of the Journal, the Publication Committee should have full charge (of course under the auspices of the Board of Trustees to which it is

directly responsible) of all the Society's publications. The editors of the two publications should be directly responsible to the Publication Committee in carrying out the policies which it adopts. The Editor is also inclined to recommend that the Society's editors shall not be voting members of the Committee on Publications since their duties are primarily executive.

Manuscript Statistics

Manuscripts received, 113.

Manuscripts published in 1921, 73.

Manuscripts received in 1921, published in 1922, 17.

Manuscripts listed on Columbus program and never received, 29.

Manuscripts returned to the author for revision and never sent back, 8.

Manuscripts rejected under Regulation I (published elsewhere before receipt in this office), 2.

Manuscripts rejected under Regulation 1 (because of general poor quality), 1.

Manuscripts rejected under Regulation IIa (because they contain nothing essentially new), 4.

Manuscripts rejected under Regulation 11d (because of advertising character), 2.

Manuscripts received but not yet published because of precedence given to papers of greater importance (would be returned to author upon request), 2.

Manuscripts recalled by author, 1.

Manuscripts still in hands of Associate Editor, 1.

PUBLICATION STATISTICS

Original Papers Classified According to Subject Matter.

Subject	No. of Papers	Pages	No. Contributors
Apparatus and Methods of Measurement.	5	49	5
Chemistry and Physics of Ceramic Materials	5	68	3
Refractories and Furnaces	18	172	18
Whiteware, Pottery and Stoneware	10	88	7
Art	2	12	2
Heavy Clay Products including Terra Cotta	10	71	8
Glass	11	153	13
Enamels	9	120	11
Cement, Lime and Plaster	3	23	5
Totals	73	756	72

Abstracts Classified According to Subject Matter.

Subject	No. of Papers Abstracted	Pages
General and Miscellaneous	73	20
Apparatus and Instruments	30	13
Refractories and Furnaces	124	35
Chemistry, Physics and Geology	121	32
Abrasives	3	1½
Whiteware and Porcelain	40	14¼
Heavy Clay Products	30	6
Glass	119	27¼
Enamels	17	4
Cement, Lime and Plaster	81	25¼
Totals	638	178

Abstract Costs.

Month	Printing (Approx.)	Stipends to Abstractors
January	$39.34	$38.72
February	38.21	16.10
March	53.79	34.02
April	37.18	5.76
May	56.20	38.66
June	76.54	22.28
July (No abstracts in July)		
August	50.58	31.30
September	51.76	31.21
October	62.72	36.77
November	22.61	8.43
December	46.37	4.02
	$535.90	$267.19
	Total	$803.09

Total Publication Costs Exclusive of Salaries.

Month	Cuts	Postage	Composition	Total
January	$55.39	$10.24	$658.16	$723.79
February	70.51	17.71	691.48	779.70
March	74.23	14.01	655.96	744.20
April	24.33	13.08	558.78	596.19
May	96.16	27.31	974.31	1097.78
June	34.54	49.26	747.87	831.67
July	107.36	19.90	725.61	852.87
August	53.57	20.33	729.26	803.16
September	57.37	17.33	762.38	837.08
October	59.40	19.76	729.66	808.82
November	37.73	17.46	617.93	673.12
December	24.20	19.45	1004.16	1047.81
Totals	$694.79	$245.84	$8855.56	$9796.19

REPORT OF COMMITTEE ON DIVISIONS AND SECTIONS

Dear Sirs:

This committee took under consideration the report of last year's committee which was not adopted. Nothing was found objectionable in the report and the committee has no recommendation for amendment of it.

Local Sections. The matter of redistriction of local sections was considered. Action of this committee in conjunction with the membership committee brought out a great many suggestions as to changes which could be made with profit.

The consensus of opinion is that local sections in general, as they have functioned in the past have been of doubtful value as an asset to the Society. It is further believed that the potential possibilities of local sections are sufficiently great to justify their continuance. In order that these possibilities be realized, it seems advisable that the sections be redistricted. It is also advisable to keep the main office of the Society in closer touch with the activities of the sections and these activities should be modified in some such way as to arouse more interest and get a larger attendance. Based upon these opinions, the committee believes that the usefulness of the local sections would be increased by taking the following action:

1. Endeavor to promote the formation of the following local sections:

a—New England (O. K. as is).
b—New York City
c—New Jersey (O. K. except N. Y. members to be split off).
d—Pittsburgh (O. K. except Beaver Falls and East Liverpool split off).
e—Philadelphia.
f—Beaver Falls.
g—East Liverpool.
h—Zanesville.
i—Cleveland.
j—Columbus.
k—Detroit.
l—Chicago (O. K. as is).
m—St. Louis (O. K. as is).
n—Pacific Coast.

2. The Secretary to carry out the program by selecting some live man in each of the above proposed districts and urge him to obtain signatures of ten men to a petition requesting the Board to grant a charter to the section.

3. Recommend to the Board of Trustees that petitions for formation of the above sections be granted.

4. Eliminate all fixed boundaries of local sections, leaving choice entirely to members.

5. Recommend to Board the local sections be not given funds of the parent Society.

6. Recommend to the Board that a uniform questionnaire be mailed from the Secretary's office every three months to the secretary of each local section, this questionnaire to cover activities of the section during the preceding three months. Responsibility for obtaining reports should be on the Secretary of the Society and he should repeat the questionnaires until he gets the report.

While it seems inadvisable to endeavor to organize any more sections at this time, opportunities should, of course, be left open to members to organize a local section wherever there is sufficient interest to make it seem likely that a section would function properly.

Divisions. The divisions are performng excellent service, both to their own members and to the Society. They seem to be the most logical sub-division into which the Society should be divided and the medium through which it may well hope to achieve its greatest aim, viz: promotion of ceramic art and science.

New Divisions. There is a great diversity of opinion as to how far the sub-division of the membership of the Society into new divisions should go. If it were desired to form a separate division to accommodate each group of members representing a given form of ceramic activity, it can readily be seen that so many divisions would be required that their very number would defeat the aim of having such sub-divisions.

On the other hand, in order for the division to function with their maximum degree of efficiency, it is necessary that each one be so constituted as to enable its members to work in harmony and to cooperate freely without prejudicing their personal or business interests.

When the membership of a disivion is so constituted, it is obvious that the membership will support it mentally, physically and financially. If not so constituted, the division is likely to suffer from lack of support by those members who feel that their energies are being wasted for the promotion of some business foreign to their own.

This committee does not wish to make a recommendation for the formation of any specific division. It does wish to express its opinion that the initatve for the formation of a new division should come from those who wish to have such a division formed. That any group of members wishing to form a new division should secure sufficient signatures to a petition and present this with all the arguments they have in favor of such a division to the Board of Trustees.

The committee would recommend that the Board of Trustees weigh carefully all evidence available, pro and con, bearing upon the question of new divisions. It is the opinion of the committee that no petition for new divisions shauld be granted unless the evidence fully justifies the same and the burden of proof should rest with the petitioners.

J. B. SHAW, Chairman.

REPORT OF MEMBERSHIP COMMITTEE

Your Committee on Membership respectfully submits to the President and Board of Trustees the following report for the year 1921:

No circular letters were sent out the first part of the year, but there has been a great deal of personal solicitation and a great deal of effort expended in trying to interest people who are not already in the Society.

It is gratifying to be able to report that the various Division Membership Committees are much more active than in previous years and it is our belief that these Division Committees, if not already so, will be one of the Society's strongest agencies for interesting and securing new members; chiefly on account of the efforts of each of these Divisions being along definite lines and of special interest to the prospects on their several lists. Two or three of the Divisions have shown particularly pleasing results along these lines.

The Enamel Division has increased its membership over 27%. The Terra-Cotta Division has secured practically every available member in every terra-cotta plant as a member of the Division. Not all of these members are members of the Society, but every effort is being made to secure them.

If the Divisions have members who are not members of the parent Society, it is a very good indication, as it means they are reaching people who would not be interested in ceramics in general and will eventually interest them enough so they will join.

A special effort has been made this year to secure a mailing list of all those who might in any way be interested in ceramics. A list of this sort is extremely hard to get, and all who can in any way contribute to this list are urged to do so. It is necessary to have not only the names of the manufacturing concerns, but also the names of the executives and technical staffs.

The assistance of Mr. Ross C. Purdy has already been felt by the Membership Committee, not only in the assistance the office has given in mailing out literature but also by many helpful suggestions and the creation of a great deal of enthusiasm.

Included in the literature sent out to prospects were the two advance notices of the meeting to be held at St. Louis—February 27

to March 3, 1922—giving a partial list of papers to be read. These notices were sent to—

Persons	205
White Wares	287
Heavy Clay Products	614
Glass Refractories	9
Refractories	339
Enamel Ware	175
Art	76
Glass Manufacturers	384
Associations	45
Magazines	35
Government Officials and Educators	19
Total	2,188

In these folders were also included the folder, "The American Ceramic Society, What It Is and What It Does." A copy of this was also sent to each member of the Society. A follow-up letter is to go to each one who received the advance notice. It is also the plan to have a letter and literature sent out to each member of most of the Associations, such as the

Paving Brick
Common Brick
Wall Tile
Sanitary
Abrasive
Electrical Porcelain
General Ware
Terra Cotta
Sewer Pipe

The following is a list of members as shown December 31, 1921:

Honorary	3	
Active	389	(Active resident, 370)
		(" foreign, 19)
Associate	958	(Associate resident, 831)
		(" foreign, 127)
Corporation	139	
Total	1,489	

Your Committee on Membership wishes to recommend that the Society proceed along the following lines in the securing of additional members and an increased revenue:

1. Encourage the increase in activities of Division Membership Committees as much as possible.

2. Redistrict and encourage the formation of as many local sections as it seems wise to.

3. Complete as far as possible the mailing list now partially prepared.

4. Systematically canvass those on the mailing list in the best manner that our finances will permit.

5. Bring the activities of the Society to the attention of the public in as many ways as possible and consistent with good judgment.

6. Try to develop methods of interesting the consumers as well as the producers with a view of their closer co-operation.

7. Create a group of members to be known as Perpetual Members, who will be exempt from dues after making an initial payment of $200.00. The interest from this will be used for current expenses until the death of the member, after which time the interest will accumulate in a research fund, the interest from which is to be spent according to the wishes of the Board of Trustees unless definite action is taken by the Society so as to some other disposal.

8. Create a similar group to be known as Perpetual Corporation members, who will be exempt from dues after making an initial payment of $600.00. The interest will be used for twenty-five years for current expenses after which time the interest will accumulate as in recommendation 7.

9. Make the officers of the foreign Ceramic Societies Honorary members of the American Ceramic Society during the time which they are in office.

10. Encourage the Local Sections to hold joint meetings with other Societies and thus interest others in our work.

Your Committee wishes to express its appreciation to Mr. Binns, Miss Binns, Mr. Purdy and the Division Officers for the assistance they have given the Membership Committee. The chairman also wishes to express his thanks to the members of the Committee for the work they have done and the suggestions they have made.

Respectfully submitted,

COMMITTEE ON MEMBERSHIP,

F. H. RIDDLE, Chairman.

MEMBERSHIP COMMITTEES

Enamel Division

B. T. Sweely, Ch.	B. A. Rice	F. G. Jaeger
C. E. Smoot	E. E. Geisinger	R. R. Danielson

Glass Division

H. W. Hess, Ch. S. R. Scholes

Refractories Division

W. E. Dornbach, Ch.	G. W. Greenwood	P. A. Boeck
W. F. Rochow	D. A. Moulton	W. K. Brownlee

REPORT OF THE COMMITTEE ON CO-OPERATION FOR THE YEAR 1921-22

The Committee on Co-operation has been very inactive during the past year and there is very little of moment to report. There are two reasons for the inactivity, one being, the present Committee was not organized until in July, and secondly, in September the Co-ordinating Service Council was recommended at a special executive conference held in New York, which absorbed the duties of the Committee on Co-operation. Thus, the latter Committee became a "fifth wheel" on the wagon, and its scope of activity has really never been made clear.

However, it would be an error to state the Committee was of no service to the Society whatever. Names and addresses of certain cement and brick manufacturers were secured for the Membership Committee. Names, addresses and officials of various trade associations in the ceramic industry, with whom the American Ceramic Society might co-operate in research or other activty, were supplied to the Secretary. This list included associations in the heavy clay products, pottery, wall tile, enamel and glass industries, as well as clay mining and the State Geological Surveys.

The Committee sought co-operation with the Gas Association in connection with their questionnaire, but before the Committee could be of any aid the Gas Association concluded that it would not be profitable to follow up the questionnaire.

It might be added that the Chairman of the Committee sought an an interview with the conservation engineer of the Portland Cement Association, for the purpose of finding out if the Society could in any way co-operate with the Portland Cement Association. It was learned that the Cement Association would be interested in co-operating with the Refractories Division on the subject of refractories for cement kilns. To date the Portland Cement Association nor any individual cement companies have shown any interest in the American Ceramic Society. With the possibilty of research on cement refractories, a point of contact has been established, and it is not at all unlikely that cement companies will be more interested in the Society if this point of contact be developed. The Committee on Co-operation earnestly hopes that the Refractories Division follows this point up with due consideration.

At the last annual meeting of the American Ceramic Society, Mr. B. T. Sweely, of th Coonley Manufacturing Co., Cicero, Ill., intro-

duced a motion advocating co-operation with manufacturers of lead products in obtaining data on lead poisoning, blue prints of dustproofing machinery, and other information that would be of value to prevent radical legislation against lead. This subject was brought about by a talk by Mr. Wilson, a representative of the National Lead Co. of Chicago, before the Chicago Section of the A. C. S. The Chicago Section then appointed Mr. Sweely to make recommendations before the American Ceramic Society to consider a way to prevent legislation in states which would restrict the use of lead compounds and which might work to the hardship of many ceramic manufactories.

The above matter was left to the charge of the Committee on Co-operation to act on, but the present Committee which, as was stated, was not organized until the summer, was not aware of this matter and hence no action has been taken.

With the coming meeting the Committee on Co-operation automatically disbands, and it is recommended that the matter of lead poisoning be brought to the attention of the proper committee for further consideration.

Respectfully submitted,

F. I. STEINHOFF, Chairman.

REPORT OF COMMITTEE ON PAPER AND PROGRAM

Having the secretaries of the different divisions the members of this committee has proven of great value. Each and every one has done much that is reflected in the contents of our Journal and in the success of the technical programs at the Chemical Show and at the general meetings.

The co-operation from the Organizing Secretary has been especially valuable to this committee.

There is nothing of the spectacular in our results and any joy which we may have had in these is in the same measure as the hard work we have put into it. Our only recommendation at this date (January 7th) for next year is that each division in considering the election of its Secretary remember that they are also selecting a member of this committee.

R. D. LANDRUM, Chairman.

Cleveland, O., January 7, 1922.

REPORTS OF INDUSTRIAL DIVISIONS

Report of the Art Division

The Art Division, as its name implies is that Branch of the American Ceramic Society which devotes its activities and researches in the interest of the development of the artistic and decorative fields of ceramic work.

....**What these Activities Include**—Broadly speaking these activities include discussions, investigations and researches in connection with shape construction, ceramic draughtsmanship, design, decoration, modeling, ceramic sculpture, individual and commercial decorative processes, and the standardization of these in connection with the various types of ceramic wares. For instance, the technique and practical knowledge essential to whiteware practice is altogether different from that required in the manufacture of tile and architectural faience; and in connection with the various decorative processes, the successful execution of works in overglaze, underglaze on the clay or biscuit, stained clays and glazes, and with the mechanical processes, the problems surrounding each one of these are not only widely different in character, but they require a different technique and type of decoration.

What the Art Division Has Done During the First Year of its Existence

1. Submitted outlines on organization and development in relation to activities. The paper by Mr. L. V. Solon dealing with glaze and color development for decorative work is a most valuable contribution vitally concerning the technical man as well as the ceramic artist. The question of suitability and standardization of the ceramic color palette is a problem that varies according to the conditions involved, but it is a problem which must be solved if we are to obtain satisfactory results; and this is only one of many developments which cannot be attacked unless the technical man and the artist work together.

2. The officers of the division have inaugurated their membership campaign, and have compiled a list of over two thousand names of prospective members. This list is not nearly complete but it embraces the names of individuals in the industrial and educational ceramic fields.

3. In addition to the usual organization communications, over one thousand letters and reports on Art Division activities have been sent

out at no expense to the parent organization. These communications consist of letters to officials of other organizations in the interest of industrial schools, questionnaires, membership campaigns, letters to officials of the A. C. S. on reorganization matters, exhibitions, etc.

4. The Art Division has advocated and succeeded in getting the Society to adopt the policy of holding exhibitions of ceramic work at the annual conventions and also at the Chemical Exposition in New York. This is an important innovation, and one that will do much to increase the influence of the Society.

5. In connection with the Society publication The Journal the Art Division is advocating a type of publication which will include matter of interest to the practical potter, decorator and student in ceramics.

The Present Program of the Art Division.

1. The development activity which most concerns not only the Art Division, but all those interested in the ceramic industry is the establishment of government industrial schools. The American Ceramic Society through the Art and Whiteware Divisions must exert every influence to establish suitable schools in localities most in need of these. The only logical way to assist in bringing about such a condition is to formulate a tentative program covering such matters as organization, essential personnel, curriculum, locality, equipment and cost involved, and to present such data to the officials of the Society for further recommendations, and then to enlist the active interest of such bodies as the U. S. Potters' Association, the Associated Tile Manufacturers, the terra-cotta group, the various manufacturers outside these organizations, and the local bodies—the chambers of commerce and educational boards and every other means to attain the degree of publicity which will lead to direct action. The establishment of industrial art schools in districts like Zanesville, East Liverpool, Wheeling and other pottery centers will be a long step toward the realization of a National Science and Art Department at least the equvalent of those functioning in the countries of our commercial rivals. The Art Division is working unceasingly to assist in bringing such a condition about.

2. Research work in ceramic draughtsmanship, ceramic shape construction, including working drawings for models, blocks and cases, and molds. Practically no attention is given to these activities, yet a reasonable amount of applied practical knowledge will result in vastly increased efficiency, a great saving in plaster and clay material, and better potting with decreased loss.

3. Outlines for research work in mechanical and manual decorative processes. The condition of "secrecy" which for so long surrounded

the technical and practical potter still exists with the decorator. Many decorative specialists engaged in this country retain control of formulae and processes, many of which are not only old fashioned and obsolete, but which could be used to a desired degree of efficiency if these were properly chartered and subjected to competent direction and supervision.

It is part of the Art Division program to classify those decorative processes in present commercial use, giving formulae and methods, accompanied with illustrations of types in the various stages. This will eventually result in the standardization of the most generally used processes and open the field to many high class decorative artists who have heretofore been barred because of their lack of knowledge of the practical part of the work.

4. **Outlines for research work in the field of ceramic instruction.** Considerable work has already been done in connection with formulating practical courses suitable for school work. The result of this will be published in The Journal in the near future. Many educational forces are interested in the possibilities involved in ceramic art instruction, but too little is known of the requirements. It is part of the program of the Art Division to not only co-operate with those schools needing information and assistance, but to standardize those processes which are suitable for school work.

5. **Exhibitions and publicity.** The general public and even the artist himself is not so concerned about the technique and exposition and discussion of methods as he is about the finished result. No artist would gain a reputation by simply writing and talking about his work. He must exhibit it. The same conditions govern any industrial activity and particularly that of the ceramist. As a national organization, attempting to cover the entire industrial and educational fields we would be seriously limiting our possibilities of expansion and consequent influence if we neglected the opportunity to exhibit ceramic wares either as concrete examples of some specific development or in connection with some standard of properties, quality or production method. We would become an introverted organization possessing no interest to many allied activities. The exhibits at the annual conventions could properly be chiefly technical in character, but when the A. C. S. is represented in national expositions and exhibitions the exhibit should surely be as comprehensive as space will allow. Our organization has an opportunity to exhibit American ceramic works afforded by no other group of interests. Everyone familiar with national and international expositions knows the time and labor involved in visiting the various ceramic displays. The A. C. S. is in

Property of
Research Division

a position to arrange an exhibit which will include practically every type of product made in the country. The value of such an exhibit both to the ceramic student and to the potter is obvious and needs no further comment here. The Art Division is co-operating with the other divisions in the interest of such exhibitions. The A. C. S. will have exhibits at the coming convention in February and at the Chemical Exposition in New York in September. When the benefits derived from such action are definitely recognized steps will be taken to establish a permanent exhibit or museum in the headquarters of the society. This will afford the scientist, the practical potter and student opportunity to examine actual examples of every type of ceramic work.

6. A. C. S. Interest in American Museums. Everyone interested in historical pottery is aware of the fact that no technical or practical information is offered by museum authorities, or that no such information accompanies the historical data usually attached to each exhibit; nor is it published by the museum authorities in separate form. Yet such information contributed by authoritative sources would be of unquestioned value to the industrial concerns interested in such types. While it would no doubt be a difficult matter for an individual to be instrumental in creating such a condition, it is easily possible that the A. C. S. might be the determining factor which would result in the compilation of a technical catalogue for one of the larger museums. If such a course were followed there is little doubt that the other museums would adopt this practice. Incidentally, the museum authorities would be quick to see that this would lead to a greatly increased interest in the exhibits. The Art Division is taking steps to approach certain of the museums with a view of ascertaining the probability of undertaking such a work.

ANNUAL REPORT OF THE ENAMEL DIVISION

For the Year 1921-22

The Enamel Division during the past year has shown that steady growth in membership and increased interest in its varied activities which can be expected of a Division which is making continued progress.

The enrollment in the Division as reported at the last meeting of the Society was as follows:

Corporation Members	8
Active Members	16
Associate Members	106
	130

On January 1st of this year the membership had increased to the following numbers:

Corporation Members	18
Active Members	39
Associate Members	120
	177

This gives an increase of 47 members to January 1st, which is approximately equivalent to the numerical increase for the past year. The percentage increase was about 38 per cent, a very gratifying increase in the membership in view of the past unsatisfactory business condition.

The folowing officers and committees have served during the past year:

Officers

Chairman—E. P. Poste, Elyria Enameled Products Co., Elyria, Ohio.

Secretary—R. R. Danielson, Bureau of Standards, Washington, D. C.

Councillors—H. F. Staley, Metal & Thermit Corp., New York; B. T. Sweely, Coonley Mfg. Company, Cicero, Illinois. R. D. Landrum and J. W. Sanders are the two councillors elected in 1920 for the term ending February 1922.

Committees

Membership—Chairman, B. T. Sweely; F. J. Jaeger, B. A. Rice, E. E. Geisinger, C. E. Smoot and R. R. Danielson.

Standards—Chairmna, L. J. Frost; B. T. Sweely, C. H. Stone, R. R. Danielson and R. D. Cooke.

Co-operation—Chairman, R. D. Landrum; C. A. Blackburn, J. E. Hansen, H. P. Reinecker and Ralph Dimick.

Rules—Chairman, J. B. Shaw; Dewitt Riess and R. D. Wells.

Research and Development—Chairman, R. R. Danielson; J. A. Aupperle, D. M. Buck, R. D. Cooke, H. C. Arnold, J. F. Bardush, H. B. Tyler, J. S. Grainer and E. P. Poste.

The Divisional Committee on Research, composed of representatives of various enameled ware and steel and iron manufacturers, has co-operated with the Bureau of Standards in some field work on fish scaling The committee met in Cleveland, Ohio, June 16, 1921, when plans were laid for co-operative work based on the conclusions from the laboratory tests conducted at the Bureau of Standards. Due to unforeseen conditions it has been impossible to make any progress on the co-operative work dealing with ingot iron, although plans are now under way for furthering this phase of the work.

The co-operative work on the sheet steel phase of this investigation has made excellent progress with the preparation of some 500 sheets of steel by the American Sheet and Tin Plate Company, which were fabricated and enameled in the plants of the Columbian Enameling and Stamping Co., the Crunden Martin Manufacturing Co., and the Lisk Manufacturing Co. The results proved sufficiently interesting so that a second lot of 1,000 sheets of steel has been prepared by the American Sheet and Tin Plate Company for drawing and enameling at the Lisk plant. The results of the work of this Committee have been very gratifying and have shown a splendid spirit on the part of both the metal manufacturer and enameler to work together through the Enamel Division for the elimination of the troubles of the industry.

The Committee on Rules has provided for certain changes in the rules of the Division to conform with changes in those of the Society. These will be submitted to vote of the Division as soon as certain other points in regard to methods of selecting officers of the division are definitely settled by the Society's Committee on Rules.

The Membership Committee has increased the enrollment of the Division 38 per cent. during the year, showing a continued growth in the membership of the Division as well as in its activities.

The divisional secretary has prepared two general bulletins to all enamelers during the year as a means of circulating the plans for activities of the division. The last circular in regard to the program for the coming meeting has shown that material is ready for the finest meeting in the history of the Division, and is indicative of the helpful

spirit of co-operation being developed in the enameling industry by the members of this Division.

Respectfully submitted,
R. R. DANIELSON,
Secretary.

January 15, 1922

BY-LAWS

Of the Enamel Division, American Ceramic Society

Adopted by Division, December 15, 1919

I. **Purpose:** The purpose is to stimulate interest in the technical development of the Enameling Branch of the Ceramic Industry through:

(1) The presentation and discussion of scientific papers relating to the raw materials, processes of manufacture and finished products of the same.

(2) The consideration of any scientific or industrial problems pertaining to metal enameling, excepting those relating solely to trade, prices, labor, tariff, sales methods, etc., providing that this shall not be interpreted to exclude the discussion of cost of manufacture or the application of cost of manufacture or the application of efficiency methods to manufacturing problems.

(3) The promotion of co-operative scientific and industrial research in metal enameling.

II. **Membership:** The membership shall consist of all members of the American Ceramic Society interested in enameling who shall indicate their desire to join the Division.

III. **Officers:** The officers of the division shall consist of a Chairman and a Secretary-Treasurer, who shall perform the duties ordinarily pertaining to these offices. The officers and a Council of four members as provided by the Rules of the American Ceramic Society, shall constitute an Executive Committee, which shall manage the affairs of the Division.

IV. **Dues:** The Division may levy upon its members such dues as a majority of its enrolled members approve, providing that such dues are first sanctioned by the Board of Trustees of the American Ceramic Society.

V. **Meetings:** The Division shall meet in conjunction with the annual meeting of the parent Society, and at such other times and places as the Executive Committee shall decide.

VI. **Standing Committees:** (1) The following standing committee shall be appointed by the Division Chairman: Membership Committee, Rules Committee, Co-operation Committee, Standards Committee.

(2) The Chairman shall appoint a representative of the Enamel Division to serve on each of the following committees of the American Ceramic Society: Group on Standardization of Tests, one representative; Group on Standardization of Products, one representative; Committee on Research, one representative; Committee on Data, one representative.

VII. **Special Committees:** The Chairman of the Division shall appoint such Committees as he may deem necessary, all committee appointments to be subject to the approval of the Executive Committee of the Division.

VIII. **Rules Governing the Presentation of Papers:** (a) The time allowed for the presentation of any paper or discussion before any meeting of this Divisoin shall be limited to fifteen minutes unless otherwise ordered by vote of the members present. (b) The presentation of details of procedure or processes of established practice is to be discouraged, save as essential for the purpose of criticism or development of new ideas. (c) Sets of numerical data or values should be presented in the form of lantern slides or diagrams. (d) Papers dealing with materials or products designated only by trade names may not be presented before the Division unless the trade name is one in general use for a material of well-known composition, or unless sufficient data is given to completely identify the material in a scientific manner. (e) All papers and written discussons presented before the Division become thereby the property of the American Ceramic Society for such use as its Publication Committee sees fit.

IX. **Amending the By-lwas:** Any proposed amendment to this Constitution must be presented in writing at a regular meeting of Section and, if approved by the Committee on Rules or by any five members, must be printed on a ballot and sent out. If the said letter ballot shows an affirmative vote of not less than two-thirds of the total vote cast within thirty days after meeting, then the same shall be declared carried and shall at once become effective.

X. **Quorum:** Ten members shall constitute a quorum. A majority shall rule except as otherwise specified in these By-laws.

REPORT OF THE GLASS DIVISION OF THE AMERICAN CERAMIC SOCIETY FOR 1921

At the annual meeting of the Glass Division, held in Columbus, on February 22nd, 1921, the following officers were elected:

Chairman—Wm. M. Clark.
Vice Chairman—J. C. Hostetter.
Secretary—E. W. Tillotson.
Councillors—H. L. Dixon and C. O. Grafton.
Chairmen of Committees were also elected as follows:
Rules—R. J. Montgomery.
Co-operation—G. W. Morey.
Membership—H. W. Hess.
Standards—A. Silverman.
Sections and Divisions—J. W. Cruikshank.
Research and Development—E. C. Sullivan.

An invitation to attend a joint conference wtih the Society of Glass Technology in England in 1922 was presented, and it was voted to investigate the cost of the trip and to determine how many members of the Society might be interested. Mr. C. O. Grafton kindly undertook this inquiry and reported at the summer meeting that 27 had indicated their intention of accompanying the party, while about 100 members desired further particulars. As a result it was voted by those present at the summer meeting "that the Glass Division recommend to the Board of Trustees that the invitation of the British Society be accepted." At that time an invitation was also extended to the Glass Container Association to join the party and to participate in this conference.

Later the Secretary was appointed to head a committee to arrange for the details of the trip. Acting in accordance with the sentiment expressed by those interested and with the suggestions of Dr. Turner, it was decided that the trip should be made after the holiday season; that is, early in September. The Secretary is now in communication with the membership for the purpose of determining the wishes of the party, so that the details of the trip may be adjusted thereto.

With respect to committee activities, particular attention is called to the Research and Development Committee, the Committee on Standards and the Committee on Co-operation. The former committee has taken action to encourage the study of glass in institutional and in individual laboratories by arranging to furnish investigators with glass of known history and of desired composition and of desired shapes. The following editorial in the January issue of our Journal is to be given wide publicity, and similar notices are to be inserted in the several scientific publcations:

"The Research Committee of the Glass Division of the Society has perfected a plan for providing glass of desired composition and desired form for investigators in this field. The material will be supplied free of charge, and no limitation as to the nature of the research will be imposed. The recipients of the material will be under no obligations except that of publication of the results of their investigations. The Committee, however, requests that wherever possible the Journal of the American Ceramic Society be given preference in reporting the results. Persons who are interested are requested to address their inquiries to one of the following members of the Committee of Research: E. C. Sullivan, Corning Glass Works, Corning, New York; E. W. Washburn, University fo Illinois, Urbana, Illinois; R. B. Sosman, Geophysical Laboratory, Washington, D. C.

"This action of the Glass Division sets an example which, with appropriate modifications, might be followed by every division of the Society. Knowledge of where materials for research may be secured is not as widespread as it should be, and research workers in all ceramic lines would welcome an agency to whom inquiries can be directed and whose co-operation can be relied upon in securing such materials."

The Committee on Standards has under consideration the U. S. Bureau of Standards' "Specifications for Limestone, Quick Lime and Hydrated Lime for Use in Glassmaking," the A.S.T.M. Standards for "Burned Lime and Hydrated Lime for Glassmaking," and the Glass Division's "Standards and Specifications for Glasshouse Refractories." This committee is making excellent progress and will probably present recommendations for Tentative Standards at the St. Louis Convention.

The Committee on Co-operation made a report at the New York meeting on September 15th-17th, 1921, and this is prsented herewith:

Rport of the Committee on Co-operative Research of the Glass Division of the American Ceramic Society

The Committee on Co-operative Research of the Glass Division of the American Ceramic Society was appointed to assist the Division of Research Extension of the National Research Council in promoting co-operative research in the glass industry. In February the Committee sent out a circular letter to the members of the Division, requesting a statement from the members themselves of the problems which, in their judgment, should be considered by the Committee. The replies received were classified, and arrangd in tabular form as follows:

A. Glass technology proper.
   1. Physical properties of glass:
      (a) Viscosity of molten glass, especially factory methods for determination.

(b) Surface tension of molten glass, especially factory methods for determination.
(c) Density of molten glass, especially factory methods for determination.

2. Chemical studies on glass:
(a) Correlation of physical properties with composition.
(b) Reactions taking place in glass manufacture, with especial reference to the rate of evolution of gas.
(c) Gases dissolved in glass.
(1) Effect of temperature and duration of fining.
(2) Effect of chemical composition.
(d) Development of colored glasses.

3. Manufacturing problems:
(a) Correlation of fining temperatures with physical properties.
(b) Correlation of finishing temperatures with physical properties.
(c) Study of methods of furnace control, such as devices for measurement of temperature, of velocity of gas and air and rate and completeness of combustion.

B. Problems of furnace construction.

1. Refractories:
(a) Improved material for tank walls.
(b) Effect of special cements and coatings on furnace and tank life and efficiency.

2. Furnace and tank design.

In April a call was received from the Division of Research Extension of the National Research Council requesting a report from the Committee for its meeting in Rochester, April 28th. In that report it was recommended that the question of co-operative research be taken up with the manufacturers, and this recommendation was approved by the Division of Research Extension. In view of the present business conditions, not only in the glass industry but in all other lines, it was judged advisable to defer further action until a more opportune time.

Respectfully submitted in the name of the Committee,

GEORGE W. MOREY, Chairman.

The membership of the Glass Division is now 220, an increase of 18 per cent since the last meeting.

Respectfully submitted,

E. W. TILLOTSON,

January 4th, 1922. Secretary.

Tentative Specifications for Limestone, Quick lime and Hydrated lime for use in the Manufacture of Glass

The Committee recommends the adoption of specifications as given in Circular 118 of the U. S. Bureau of Standards. The specifications proposed by Dr. M. E. Holmes have been given careful consideration, but our Committee deems it inadvisable to change the specifications in Circular 118 in any way at present.

Glass House Refractories

In view of the limited data available, our Committee considers it inadvisable to propose a large number of tentative specifications for glass house refractories until the question has been given a more careful practical study. We, therefore, propose the following as a nucleus to which other specifications may be added from time to time.

1. Glass Melting Pots.

(a) The softening point determined as per American Ceramic Society's specifications from cones made of the raw pot mix, shall not be less than that of Seger Orton cone 29, and the softening point of any individual plastic clay constituent shall not be less than cone 27.

2. Flux Blocks.

(a) The softening point determined as per American Ceramic Society's specifications from sample of the burned block shall not be less than Seger Orton cone 27½.

(b) The porosity of Tank Blocks shall not be over 26 per cent.

3. Clay Refractory Blocks and Bricks.

(a) Suggested that the question of load test, reheating test and softening point for refactory blocks be taken up with Committee C-8 of the A. S. T. M., keeping in mind that the refractories requirements of the glass industries is somewhat more severe than many present-day fire-brick will satisfactorily stand.

4. Silica Refractories.

(a) Silica refractories should give forth a good ring when struck.*

(b) The specific gravity** should not be over 2.38 for brick made from Medina Quartzite, nor more than 2.42 for brick made from Baraboo Quartzite.

(c) Silica brick should not contain over 3 per cent of CaO, nor over 1.75 per cent of Al_2O_3.***

These recommendations will be submitted to the General Committee on Standards of the A. C. S. for their consideration and for final approval by the Society at large.

Respectfully submitted.

A. SILVERMAN,
Chairman, Committee on Standards
Glass Division, A. C. S.

* It should be noted that the ring of Baraboo brick is not quite as clear as is that of Medina brick and that brick which have been wet are apt to give forth a dead sound when struck.

** The specific gravity referred to is an approximation of the true specific gravity. Satisfactory determinations for this purpose can usually be obtained by saturating a two-inch (2") cube of the material with water and weighting.

*** Concerning other ingredients, it is considered undesirable for a brick to contain more than 0. 5 per cent of alkalies. A per cent or two or iron does not appear to affect the brick greatly, providing the Al_2O_3 is within the limit. It is also necessary that the MgO below (say 0.3 per cent or less). However, it appears hardly necessary to specify concerning these constituents because in commercial raw materials they are usually present in amounts less than above stated.

REPORT OF HEAVY CLAY PRODUCTS DIVISION

Officers:—ROSS C. PURDY, Chairman,
C. FORREST TEFFT, Secretary.

History:

The sole purpose of Mr. Purdy acting as chairman for the year 1921 was to effect organization of the Division. Over two hundred members of the Society very properly could be classified as of this Division, hence organization of the Division was merely one of crystalization of that which was already available.

Officers and Committeemen for 1922:

A nominating committee was appointed to select men to serve as officers and committeemen for 1922. They canvassed the situation thoroughly and their nominees accepted their nominations, and the Division by ballot at the 1922 convention elected the ticket so named. A solid, well knitted organization was thus assured.

Constitution:

The constitution recommended for all the Divisions by the Rules Committee, Prof. A. S. Watts, Chairman, was adopted.

Co-operative Research:

The Society through this Division is co-operating with the American Fire Brick, the Common Brick, the Paving Brick and the Hollow Tile Trade associations in the researches which these associations are financing in co-operation with the Bureau of Mines and Bureau of Standards.

Plans are being formulated for extensive co-operation among manufacturers on investigation of appliances and methods. The trade associations will be asked to co-operate in these investigations and in compilation of data. Close working contact has been established with the American Society for Testing of Materials and the Department of Commerce through representation on committees.

REPORT OF THE REFRACTORIES DIVISION OF THE AMERICAN CERAMIC SOCIETY FOR 1921-22

The Refractories Division wishes to make the following report on its activities for the year 1921-22:

At the annual meeting in Columbus in February, 1921, Mr. A. F. Greaves-Walker was re-elected Chairman of the Division. Mr. Raymond M. Howe was nominated to succeed himself as Secretary, but asked permission to withdraw his name because of his other duties in the Society. In his place, Mr. Fred A. Harvey was nominated and elected. Shortly after the annual meeting, Mr. Greaves-Walker appointed the following committees:

Committee on Co-operation: S. M. Kier, Chairman; J. D. Ramsey, R. H. H. Pierce.

Committee on Membership: W. E. Dornbach, Chairman; Percy A . Boeck, D. A. Moulton, G. W. Greenwood, W. F. Rockow, W. K. Brownlee.

Committee on Papers and Program: Chas. Berry, Chairman; I. A. Krusen, E. E. Ayars, R. M. Howe, E. T. Van Schoick, A. H. Chandler.

Committee on Research and Development: R. M. Howe, Chairman; W. H. Grant, Chas. E. Kraus, J. M. McKinley.

Committee on Standardization: J. S. McDowell, Chairman; Fred A. Harvey.

Bibliography

Probably the most important achievement of the division this year has been the compilation of a bibliography on magnesite. This bibliography appeared in the form of the first bulletin of the Division, and was sent to all members of the Division and the consumers of magnesite. The bibliography was compiled by Mr. H. G. Schurecht, Ceramic Chemist of the Bureau of Mines, with the permission of the director, from bibliographies by J. S. McDowell, L. H. Dushak, Robt. D. Pike, National Research Council, American Gas Association, American Foundrymen's Association and the literature. Secretary Ross C. Purdy collaborated with us in the assembling and issuing of this bulletin. He interested those who had information, and the bulletin was neostyled in his office. It contains titles, references, and abstracts of about 400 articles on this subject.

A second bulletin containing a bibliography on Silica Refractories is in the course of preparation. Mr. James T. Robson, Instructor in Ceramic Engineering at Ohio State, is doing the work, wtih the assistance of Mr. Schurecht and the entire Division. Several hundred titles

and abstracts have already been sent to the Secretary by members of the Division and forwarded to Mr. Robson. It is hoped that this bulletin will be ready by the 1922 annual meeting.

Further bulletins on Chrome, Sillimanite, Alumina, Spinel, Silicon Carbide, Zirconia, Carbon, Clay and specal refractories, including nitrides and oxides are simmering but have not yet come to a boil.

The fine co-operation and work of the Committees may be best shown by a study of their reports.

Report of the Membership Committee

According to your Committee's reports, the first membership list of our Division furnished to us by the Secretary, was under date of May 7, 1921. This list contained the names of 91 individual members and seven corporation members.

Through the medium of personal calls and some 205 personal letters sent out by your Chairman, not counting those sent by the other members of your Committee, the membership in the Division has been increased to 183 individual memberships and 18 corporation memberships. This list is correct to January 1, 1922.

Since January 1st we have been making a drive for new members to the Society as well as for new members for our Division. This drive we are unable to make a report on, as the cards returned, if any, are being sent in self-addressed envelopes direct to the Society's General Secretary at Columbus.

The percentage increase in personal members for our Division is 101 per cent. For corporation members, 157 per cent.

Our records show expenses to the amount fo $15.25 as accrued in conducting our campaign. This money was expended only for stationary and stamps, as stenographers' services were donated.

The entire Refractories Industry has been canvassed, especially in regards to corporation memberships and, while we have not obtained as many members as we would like to have gotten, still we have any number of promises that when business conditions improve that this matter will be re-considered. We find that every one evidences considerable interest in the work of the Society and our Division in particular, but they hesitated at this time to spend the money to obtain the services we have to offer.

We also have been directing considerable attention to enrolling as individual or corporation members those men or companies who, while not interested in the manufacture of refractories, still are large users of them and should know more about them through our Society.

There are a number of excellent prospects among this class whom your new Committee, under the better business conditions which the coming year will bring, can obtain as members.

W. E. DORNBACH,
Secretary.

Report of the Committee on Standardization, December 15, 1921

We have recommended that the committee approve those specifications which have been adopted by Committee C-8 of the American Society for Testing Materials as standard, but which have not yet been approved by our committee. Further than this we have taken no action.

We do not believe that our sub-division should initiate studies on specifications, or attempt to work out specifications independently. We can render a greater service by studying closely specifications proposed by other societies, as the Society for Testing Materials, the British Society for Glass Technology, and the British Ceramic Society. The preparation of short papers discussing the good and bad features of any such proposed tests, or of tests already adopted, and the factors which must be taken into consideration in properly interpreting them, would be helpful to those who wish to use them.

Yours very truly,
J. SPOTTS McDOWELL.

Report of the Committee on Papers, December 28, 1921

Some time after this Committee was announced, the chairman sent a letter to each member asking them to get to work and endeavor to secure suitable papers. This was followed by a second letter. On November 1st a form letter was sent to all of the members of the Refractories Division, as well as to others who are more or less interested in refractories. This letter told of the question box we would have and also asked for papers.

As a result of the Committee's work, eighteen papers have been definitely promised and a number of others have been promised tentatively or for which the subject has not been given. Special credit is due Mr. Ayars for his work in securing a large number of these papers. It is very likely that many more papers will be announced previous to the annual meeting.

The expenses of the chairman for postage for the year has been $3.30. Up to the present time reports have not been received covering expense of the other members.

Yours truly,
C. W. BERRY, Chairman.

Report of Committee on Co-operation, December 28, 1921

Replying to your letter of December 6th, I hardly have any report to submit for the Committee on Co-operation, for I really do not know what was expected of this Committee by those responsible for its creation.

It is the desire of the Refractories Manufacturers Association to co-operate with the users of refractories, and I might suggest that if the American Ceramic Society would make an effort to secure members among the users of fire brick that it might further co-operative work.

Yours very truly,

S. M. KIER, Chairman.

The research work of the Refractories Manufacturers Association during the year 1922 will be conducted along the lines indicated below. Parts of this work have been started; the rest is being held in abeyance until the opportunity for its completion arises.

I. The reduction of breakage in silica brick manufacture.

II. The development and improving of testing methods.

III. The influence of the various steps in the process of manu- upon the characteristics of the finished product.

IV. The action of furnace gases upon the structure of refractory brick.

These researches will be conducted at the Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa. Many or all of the results will be of such a nature that they will be available for publication.

Report of Committee on Research and Development

The following statement was sent to each of twenty universities. These were selected because of the fact that they conducted research on ceramic problems or else maintained industrial research or metallurgical laboratories. The suggestions were evidently favorably received for several detailed replies were received.

We were advised by the University of Illinois that Problem No. 2 was being started and that they were able to secure the loan of five sets of oil burners for use during the investigation. The opinions of the individual members on the subject of fuel oil furnaces were expressed. Representative brick were secured from several manufacturers who were interested in this problem.

A reply was received from Penn State College stating that they were interested in the same problem and would undoubtedly start its investigation.

The Department of Industrial Chemistry at the University of Iowa signified interest and wished to receive additional suggestions.

A similar reply was received from the University of Wisconsin and Professor O. A. Hougen indicated the possibility of starting research on thermal conductivity.

Professor Rhodes of Cornell University stated that they were equipping a laboratory for industrial research and asked for information regarding equipment for ceramic problems. This was furnished and it is hoped that progress in this field will develop.

Thus, while the work of the committee has been by no means sensational it has at least attracted the attention of several university laboratories that have not actively co-operated with the American Ceramic Society. It is also believed that it may have supplied certain moral support to those who were planning or had already started research along the indicated lines.

The chairman wishes to acknowledge the hearty support of the officers of the division, and of the members of this committee, in answering questionnaires and in the preparation of the previously mentioned statement now appended. It is earnestly recommended that a similar procedure be pursued in the future, affording special service, if possible, to those universities that signify interest. This service might include the additional feature of summarizing the efforts of the preceding year, of offering bibliographical data on different subjects, or securing raw material. Possibly a more detailed account of each problem, indicating its application, might stimulate greater interest.

LETTER ADDRESSED TO THE UNIVERSITIES

Gentlemen:

The Research Committee of the Refractories Division of the American Ceramic Society has collected a number of possible subjects for research. It wishes to place those subjects before you at this time, hoping that perhaps some senior or graduate student may be interested in one or more of them for a thesis. The Committee does not consider that its obligation is fulfilled by simply presenting these nineteen subjects, but will hold itself in readiness to co-operate with those desiring such co-operation.

You will note that certain of these subjects are of a theoretical nature, while others combine theory with practice. If it would be desirable to secure the co-operation of some manufacturing plant, this may be possible. The Committee believes that each of these subjects should lead to results that can be applied in a practical way.

1. Reduction of kiln loss on silica shapes.

   Points

   The determination of a burning curve for Eastern and Western Ganisters.
   Determination of the temperatures at which most breakage takes place.

2. Production of a high grade fire brick for use in oil and powdered coal fired furnaces which will have necessary density and still stand thermal shock.

3. Theoretical advantage of a trydemite-cristobalite brick and temperatures at which inversion proceeds most rapidly.

4. Effect of burning time on Eastern and Western Ganisters.

   Points

   Breakage.
   Specific gravity.
   Modulus of rupture.
   Porosity.
   Amount of inversion.

5. Effect of temperature in dead burning magnesites.

   Points

   Range from caustic burned to electrically fused temperatures.
   Rapidity of setting.
   Slaking when wetted.
   Absorption of CO_2 from air.
   Effect in drying brick made from material.
   Effect in burning brick made from material.

6. Relative efficiency of high calcium lime as compared with dolomite in silica brick manufacture.

   Points

   Specific gravity.
   Modulus of rupture.
   Expansion in burning.

7. Effect of various percentages of lime, magnesia, silica and alumina on the manufacturing qualities of chrome-iron ore.

8. Effect of various percentages of lime, silica and alumina on the manufacturing qualities of magnesites.

9. Effect of the control of sizes of grain in the manufacture and use of silica brick.

10. Method of determining thermal conductivity.

11. Linings for rotary cement kilns.
12. Refractories for tunnel kilns.
13. Refractories for electric furnaces.
14. New refractory bases such as "Krausgrain."
15. High temperature insulating brick, that have little or no shrinkage at 2500° F., fuse above 2700° F., low co-efficient of expansion, and high mechanical strength at 2200° F.
16. Rapid determination of iron oxide and other fluxes.
17. Gathering of data regarding the application of a given kind of refractories.
18. The effect of iron oxide upon the fusion points of alumina, silica, aluminous clays, silicious clays, and kaolin.
19. Co-efficient of expansion of various forms of refractory magnesite.

Sincerely yours,

R. M. HOWE,
Chairman Committee on Research.

The expenses of the Secretary's office have been:

Printing	$ 9.00
Postage	6.50
Stenography and Clerical Work	7.50
	$23.00

In conclusion the Chairman and Secretary wish to express their appreciation of the splendid support which has been extended to them by the committee and the division as a whole.

Respectfully,

FRED A. HARVEY,
Secretary, Refractories Division.

REPORT OF THE TERRA COTTA DIVISION

For the Year 1921

Officers and Committees

Chairman, A. F. Hottinger.
Secretary-Treasurer, R. L. Clare.

Committee on Papers and Program

Committee on Papers and Program—W. L. Howatt, D. F. Albery, P. G. Larkin.

Committee on Technical Research—A. F. Hottinger, R. L. Clare, C. W. Hill, E. C. Hill, Alternate.

We have at present sixty-six members, representing all but two of the terra cotta companies in the United States, as well as several of the allied industries.

The Committee on Technical Research has been co-operating with the Technical Committee of the National Terra Cotta Society in some very important research work being carried on at present at the Bureau of Standards. We have two men giving all of their time at the Bureau, under the direction of P. H. Bates and the above named Technical Committee, who are securing some very interesting and important results.

Our program for the coming meeting has not been completed, but at the present time we have eleven papers and discussions for submission and expect to have more by the time the meeting is held.

Respectfully, submitted,

R. L. CLARE,
Secretary.

ANNUAL REPORT
WHITE WARES DIVISION

Officers

E. T. Montgomery, Chairman
C. C. Treischel, Secretary.

Executive Committee

C. E. Jackson, Warwick China Co., General Wares Group.
O. O. Bowman, 2nd, Fireclay & Porcelain Co., Sanitary Porc. Group.
Harold P. Humphrey, Washington Porcelain Co., Electrical Group.
John Morton, Mosaic Tile Co., Tile Group.
Thos. H. Sant, John Sant & Sons Co., Materials Group.

Members

Corporation	52
Active and Associate	287

Organization

The White Wares Division is composed of the following groups interested in the manufacture of vitreous and semi-vitreous products:

1. General Wares Group.
2. Sanitary Porcelain Group.
3. Electrical Porcelain Group.
4. Floor and Wall Tile Group.
5. Materials Group.

Due to the fact that throughout the year there has been considerable discussion relative to the formation of a separate division for the General Wares Group, the organization of the White Wares Division has only recently become stabilized. Other factors contributing to the delay in organizing were the resignation of Mr. Bleininger as Chairman, and the difficulties encountered by Mr. Montgomery, who was appointed by President Pence to fill the vacancy caused by Mr. Bleininger's resignation, in getting representatives from the various groups to serve on the Executive Committee.

However, the goal set by the officers at the beginning of the year has been reached and they can "present a smooth working, well organized division to the Society."

Activities

Activities along lines of research were allowed to lag until the organization of the division became complete—this being the plan of the officers for the year—it being realized that steps along these lines would lead to hopeless entanglements if attempted without the backing of an organization. The year 1922 will see the launching of a very active campaign of research, announcement of which will be made at the annual meeting.

The program for the annual meeting is very well balanced and should prove interesting to all the associated groups. Much is expected from the features of program, namely, the colloquiums and discussions, and if everyone present will do his share these expectations will be realized.

C. C. TREISCHEL,
Secretary.

REPORTS OF LOCAL SECTIONS

Central Ohio Section

The Central Ohio Section held two meetings during the year. The first was held at Zanesville on May 27, 1921. The meeting was addressed by R. C. Purdy on the subject of a full time Secretary, and a motion to endorse such a movement was unanimously adopted. A committee, consisting of J. D. Whitmer, Horace Crew and Donald Hagar, was appointed to draft a resolution favoring a full time Secretary and spread same broadcast.

Officers for ensuing year were elected as follows:

C. D. FRAUNFELTER, Chairman.

J. J. FRED BRAND, Vice Chairman.

DONALD HAGAR, Secy. and Treas.

A. S. WATTS, Councilor.

The second meeting was held at Columbus, on November 16. It was a joint meeting with the Student Branch of Ohio State University. The meeting was addressed by Col. Edward Orton, Jr., Dr. E. W. Washburn and Pres. F. K. Pence.

The section has a balance in the treasury of $49.97.

ARTHUR S. WATTS,
Councilor.

CHICAGO SECTION

During the year 1921 three meetings were held with programs presented as follows:

February 5.—City Club. Notes on the Acid Resistance of Enameled Cooking Utensils; B. T. Sweely; Notes on the Manufacture of Lead Products used in the Ceramic Industry, Lester T. Wilson. Attendance 22. At this meeting a motion was passed to bring to the attention of the parent Society the fact of lead poison being detrimental to the health of the workman and that the parent Society should co-operate with the National Institute of Lead Manufacturers in taking measures of precaution against such conditions.

May 23.—City Club. Reflector Enamels. Cullen W. Parmelee. Pyremetry, which covered a discussion on types used in the Ceramic industries. G. V. Nightingale and F. C. Baker.

In accordance with the request of the parent Society Mr. Chester Jones was appointed by the chairman to act as representative of this section on the nominating committee.

Messrs. Albery, Sweely and Wilkins were appointed to arrange to meet representatives of th Illinois Clay Mfg. Association with reference to the amalgamation of the Chicago Section and the Association. This matter will be taken up with the Illinois Clay Manufacturers at their March meeting 1922. Attendance 25.

November 26.—Morrison Hotel. New method of measuring porosity, Dr. E. W. Washburn. Informal talk on Photography on Enamels. J. A. Dedouch.

The annual election of officers was held at this meeting and the following were elected to hold office for 1922: F. L. Steinhoff, Chairman; B. T. Sweely, Vice-Chairman; Wm. W. Wilkins, Secty-Treas.; C. W. Parmelee, Councilor; Ed. Brockman, Chairman of Membership Committee; H. E. Davis, Chairman of Program Committee. Attendance 30.

PROPOSED SCHEDULED MEETINGS TO BE HELD IN 1922

March meeting to be held in conjunction with the Illinois Clay Manufacturers Association.

First or second week in June. Trip to Joliet via boat, visiting Power plant and American Refractories Company.

Summer meeting to be held in Danville, provided the Illinois Clay Mfg. Association hold their meeting in Chicago.

Thanksgiving—Annual meeting.

In the future we propose to write to all of this section before each meeting, in addition to the regular letter, asking them if they have any problems that they wish discussed at the next meeting, advising them of the fact that each question will be handled at the meeting or will be assigned to some member. In doing this we believe we will draw more members to the meetings.

NEW ENGLAND SECTION

There were two meetings held during the year. The Secretaries' reports of these are attached.

Interest in our meetings is confined to twenty-five or thirty men and it is with some difficulty that good meetings are arranged. Our mailing list includes 75 individuals of whom 7 are Active, 28 Associate and 40 non-members of the parent Society.

In view of the fact that the membership is small, the territory large, and the industries represented are very diversified, it is felt that the Section has done very well in keeping up as it has. There apparently is nothing to be gained by a redistricting of the Section as our meetings are now held within easy reach of a great majority of the members.

Interest in the Section would in all probability be greatly increased if new speakers were accessible for our meetings as the field among our own membership has been pretty well covered.

M. C. BOOZE, Councilor.

ANNUAL MEETINGG

January 22, 1921—The meeting was held at the Engineers Club in Boston and was called to order by the Chairman, C. J. Hudson, about 7:00 P. M. after a dinner at the club. Thirteen members were present.

The report of the Secretary and Treasurer was read and approved.

The Nominating Committee submitted their report as follows: Chairman, A. T. Malm; Councilor, M. C. Booze; Sec'y and Treasurer, S. F. Walton; Executive Committee, Browne Harding and Prof. C. L. Norton.

These nominees were elected by a single ballot cast by th Chairman, acting for the Secretary.

The following talks were given: "Some Troubles Encountered in the Manufacture of Watch Dials," F. P. Flagg, Chief Chemist, Waltham Watch Co.; "Notes on the Efficiency of Clay Crucibles," H. W. Richter of Garhart Dental Specialty Co.; "A Novel Testing Furnace," S. F. Walton, Kalmus, Comstock & Wescott, Inc.; "Application of Pyrometers to the Ceramic Industries," H. Goldsen, General Sales Manager, Wilson Maculen Co.

A general discussion followed the program.

May 26, 1921

The spring meeting was held at the Standish Hotel, Worcester, Mass. After dinner the meeting was called to order by the Chairman, A. T. Malm. There were twenty-five members and friends present.

Business

The Secretary's report of the annual meeting was read and approved.

The Chair read the notice of the request of the parent society to sections for the election of the representative from the section on the nominating committee.

On a voice vote G. N. Jeppson was elected after being nominated by C. J. Hudson; M. F. Beecher rising for a motion that nominations cease, seconded by Broga. After the motion was carried the Secretary was instructed to cast a unanimous ballot for Mr. Jeppson.

A resolution signed by five active members of the parent society, was read by M. F. Beecher after an introduction by the Chairman. On a motion by Beecher, seconded by Hudson, the resolution was approved and the Secretary instructed to forward a copy to the Board of Trustees. A copy it attached.

Since there was no further business the members proceeded to the program.

C. J. Hudson's talk on a Dressler Tunnel kiln proved interesting and instructive. He ably explained the operation of the filn. A carefully prepared curve, together with a cross section drawing helped make his talk clear. Numerous photographs were also an aid to his audience.

There followed two talks by Dr. W. D. Bancroft of Cornell University. His first subject, "Chemistry and Ceramics" treating on the plasticity of clays—gave his audience much to think about, which was later brought out in discussion. His premise of the cause of plasticity being well taken and the idea formulated it is now in condition to be proved by the chemist and ceramist. He took exception to the ceramist taking emperical data as a basis for solving his problems. This point he brought out more clearly in his second subject, "Clay and Colors," explaining the causes for different colors.

He made the point that the ceramist and chemist accept so-called facts without definite proof to substantiate them. This is especially true in the color chemistry of glasses and glazes.

On account of out of town members having to leave, the meeting adjourned without discussion of the subject on the program.

(Signed) S. F. WALTON, Secretary.

Recognizing the need for greater activity on the part of Sections, Divisions and Committees in order to insure continued growth of the American Ceramic Society as well as to allow it to acquit faithfully its present obligations to its members;

The New England Section wishes to record itself as in favor of such increased expenditures, as, in the opinion of the Board of Trustees, shall be necessary, and consistent with the income of the Society, to provide for energetic official stimulation and encouragement of the Sections, Divisions, and Committees.

Whether this be by increasing the appropriation for the secretary's office or by the appointment of a new full-time officer, such as the Organizing Secretary proposed, we prefer to leave with the Board of Decision.

We are disinclined to consider the stimulation and development of research activities as a factor in this proposition until a definte plan and suitable guarantees for continued support have been worked out between the Board and those associations who wish to undertake to finance such work.

In the event of the appointment of a full-time officer, we who have had long acquaintance with Mr. R. C. Purdy and close association with him in ceramic work, wish to endorse him most highly as being in our opinion, a man eminently fitted by training, enthusiasm and recognition in the ceramic field, for such important work.

(Signed) M. C. BOOZE,
A. A. KLEIN,
CHARLES J. HUDSON,
O. S. BUCKNER,
M. F. BEECHER.

FINANCIAL STATEMENT

Receipts —

Balance on hand January 1, 1921	$179.34	
Dues Received	13.00	
		$192.34

Expenses —

Mailing Notices—Room Deficit and Printing	72.50
Balance January 1, 1922	$119.84

The small amount collected for dues for the year is on account of the majority of members paying before the first of the year.

Respectfully submitted,
WM. W. WILKINS.

NORTHERN SECTION

Three meetings were held during the year, with an average attendance of fourteen. The April meeting was held at Toledo, Ohio, and the June and December meetings at Cleveland, the last being the fourteenth regular meeting of the Section. Thirty-two members paid dues for the year, and there are at present about 110 names on the mailing list.

The following papers and discussions were offered:

"Action of Metallic Substances on Pots and Glass," by Henry W. Hess, Toledo, Ohio.

"New Method of Pot Setting," by Wm. K. Brownlee, Toledo, Ohio.

"Tunnel Kilns," by Conrad Dressler, Cleveland, Ohio. (Illustrated with lantern slides.)

"Manufacture of Armco Ingot Iron," by T. W. Jenkins, American Rolling Mill Co., Middletown, Ohio. (Motion Picture Films.)

"Colloquium on Research in Ceramic Plants," "Problems Confronting the Local Sections, and Their Solution," by Ross C. Purdy, Columbus, Ohio, Organizing Secretary, A. C. S.

The following officers were elected for 1922: Chairman, Chas. H. Stone, Jr., Cleveland, Ohio; Secretary-Treasurer, A. F. Gorton, Cleveland, Ohio; Councilor, R. D. Landrum, Cleveland, Ohio.

The Section takes pride in the fact that it was the first to pass resolutions favoring the appointment of a general Secretary for the Society, such action having been initiated at the April meeting.

R. D. LANDRUM, Councilor.

The fourteenth meeting of the Section was held Tuesday, December 20, 1921, in the rooms of the Cleveland Engineering Society, Hotel Winton, Cleveland, Ohio, with an attendance of twelve.

After lunching together at 1 P. M., a business session was called to order at 2 P. M. with Mr. Poste presiding, and Dr. Gorton acting as Secretary. Minutes of the last (June) meeting were read and approved. Annual report of the Treasurer for the year 1921 was read and adopted. Owing to heavy expenditures in connection with the June meeting, and to the decrease in receipts which followed a lowering of dues, the Section closed the year with the treasury empty (no bills outstanding).

Proceeding to the election of officers for 1922, the slate agreed upon by the nominating committee was carried by acclamation. Accordingly the officers for the ensuing year will be: Chairman, Charles H. Stone, Jr., Cleveland; Secretary, A. F. Gorton, Cleveland; Councilor, R. D. Landrum, Cleveland.

Mr. Stone was prevented from attending by business matters which require his presence in Georgia for the next few months.

Progress report by Finance Committee appointed at June meeting was to the effect that the Society would probably frown upon the proposal to remit to each Local Section a fraction of the dues of each member residing in its territory. This matter was discussed, but no further action was taken.

In a discussion with Mr. Riddle it developed that a new Local Section might in the near future be chartered with headquarters in Detroit. Such a section would take care of points in Michigan, such as Flint, Saginaw and Grand Rapids, also possibly Toledo, Ohio.

Under suspension of the Rules, it was voted to restore the due to the former figure of $2.00. (Thirty-one members paid $1.00 each for the year 1921, and expenses during the year amounted to $71.00.)

Voted, that a committee be appointed by the temporary Chairman (Post) to take up alteration of the Rules of the Section.

The Section listened with great interest to a brief but forceful address by Mr. Ross C. Purdy of Columbus, the new Organizing Secretary of the American Ceramic Society. Mr. Purdy touched on the problems confronting the Local Sections and emphasized the possibility of doing effective work despite the apparent handicap of a small active membership. He made the very pregnant suggestion that at our next (April) meeting we strive to bring together the users of refractories and other ceramic products as well as the ceramic manufacturers.

In the ensuing discussion Messrs. Landrum and Stowe favored the idea of interesting the purchasing agents of concerns using refractories; Mr. Riddle noted the fact that many users of fire brick have only a vague notion of what constitutes a refractory, and Mr. Forsyth advanced the argument that most manufacturers are users of refractories without being aware of the fact (e. g., every power plant involves boiler settings, etc.) It was the consensus of opinion of the members that a very definite, clear-cut effort should be put forth to bring the users of ceramic products together at our April meeting.

A colloquim on the general subject of Research in ceramic plants was led by Dr. Gorton, and various members touched upon such matters as opportunities for plant research, effective scope and practical value of such work, and the proper co-ordination of research laboratory and plant. It was pointed out that papers on plant research have always formed the basis of the programs offered at our Local Section meetings, and it seemed to be the feeling of the members that this policy should be continued in the future.

Meeting adjourned.

A. F. GORTON, Secretary.

PITTSBURGH DISTRICT SECTION

February 1921—February 1922

The first meeting for the year of 1921 was held at Mellon Institute, University of Pittsburgh on June 2, 1921. The following program was given:

"A Thermal Conductivity Study of Silica Brick," E. B. Guenther.

"The Shaw Gas Kiln," Thos. H. Sant.

"Replacing Fire Clay with Silica Brick," A. F. Greaves-Walker.

"The Examination of Pottery Materials," A. V. Bleininger.

"The Glass Industry of India," G. P. Ogale.

The second meeting of the year was held at Mellon Institute, University of Pittsburgh on November 29, 1921. The treasurer reported a balance of $70.08 on hand.

The following officers were elected for the coming year: Chairman, A. F. Greaves-Walker; Vice-Chairman, A. V. Bleininger; Secretary, J .W. Wright; Treasurer, T. H. Sant; Councilor, Francis W. Walker.

The following program was then given:

Heavy Refractories—Their properties and Uses, Illustrated with Colored slides.

Motion Pictures showing Modern Methods of Manufacturing Window Glass by Machinery.

Motion Pictures "Magic Clay" from Carter Cinema showing the modeling of clay, shaping of vases, and of other beautiful creations of the potters art.

Mr. Sant of East Liverpool suggested the desirability of forming a District Section of the American Ceramic Society at East Liverpool, Ohio, and asked for an expression of the feeling of the Pittsburgh District Section. Dr. Silverman made a motion which was duly seconded and passed that the Pittsburgh District Section would look with favor upon a formal application for the withdrawal of the members in the East Liverpool District since such action would be a benefit to the members of the Ceramic Society.

Treasurer, Thos. H. Sant submitted the following report for the year of 1921:

Receipts

Balance brought forward	$44.52
Dues collected to date	87.00
Total	$131.52

Disbursements

January 13—C. C. Vogt	$ 8.69
November 22—Carter Cinema	19.00
November 29—J. W. Wright	29.55
Balance on hand November 29, 1921	78.28
Total	$131.52

St. Louis Section

February 11th.

Dinner at the Missouri Athletic Association at which thirty-one members were present.

Officers for 1921 were elected as follows: F. G. Jaeger, Chairman; C. W. Berry, Council; G. R. Truman, Secretary-Treasurer.

Program

"Industrial Conditions in Europe," informal talk by D. T. Farnham.

"Description of an Electric Furnace for Enameling," paper by H. W. C. Mehling and J. W. Carpenter. Read by Mr. Carpenter.

April 29th:

Dinner at the Annex Hotel. Twenty-nine present.

Program

"Purpose of the American Ceramic Society and its field in St. Louis," address by F. K. Pence.

"Response to Mr. Pence," by H. A. Wheeler.

Activities of the St. Louis Section During 1921

November 3rd:

Dinner at the Annex Hotel. Thirty-one present.

Program

General Discussion of the Purpose and Policices of the Section.

"A New Rotary Electric Kiln for Enameling," informal talk by J. W. Carpenter.

December 1st:

Dinner at the Annex Hotel, Twenty-three present.

Discussion of the Convention in February.

Meeting of the Convention Sub-committees.

CHARLES W. BERRY, Councilor

REPORTS OF STUDENT BRANCHES

University of Illinois

Membership of the Society: The membership now includes twenty-five paid up members.

The activities of the Illinois University Student Branch of the American Ceramic Society for the present year are as follows:

1. A smoker held at the beginning of the school year. All Ceramic students invited. No charge made.

2. A committee to co-operate with the University authorities on the Ceramic exhibit in the general Engineering. Open House. This included the assigning of shifts and operating periods to members of the society for operation of: (a) Kilns, (b) Frit Furnaces, (c) Brick Machine, (d) Repress, (e) Casting, (f) Pressing, (g) Throwing, (h) Jiggering, (i) Turning, (j) Plaster Work.

3. **Program:** The programs for the meetings of the year are divided between purely ceramic subjects and others that are of interest along related subjects. These comprise addresses on "Factory Management" and "Business Law" as well as talks based on the experiences and observations of members of the Ceramic Faculty. Discussion of thesis work is on the coming program.

Dr. K. H. Endell has just delivered an interesting illustrated lecture before the Society upon Some Phases of the Ceramic Industry in Germany.

4. **Letters:** Letters are now being sent out by the Society to all graduates of Ceramic Engineering at Illinois, asking them, in the form of a questionnaire, about their activities, opportunities, etc., in Ceramic work, with the end in view of helping the undergraduate.

5. The Student Branch of the American Ceramic Society has been represented at every meeting of the Engineering Council, the student executive body of the Engineering College.

C. W. PARMELEE, Councilor.

Iowa State College

Because of the small number of advanced students in the Department of Ceramics at Iowa State College the year has lacked in enthusiasm. With the added numbers that seem probable from now on this Branch should greatly improve. However those that profit most by the meetings gave the most loyal service and in that sense the work was worth while.

The year was used in meetings sometimes as often as once a week and part of the time longer meetings once a month. Because of

the complex student life at Ames it has been decided to arrange a regular hour in the college calendar, in school hours for the meetings, so that nothing can conflict, and so that all students can attend the meetings without sacrifice.

One very good talk was given by Professor Frank D. Paine of the E. E. Department on insulators as concerns the electrical engineer. The balance of the work was done by the young men themselves and as several of them have been actively engaged in clay business before entering college the discussions were worth while.

It is planned this year to call more often on faculty men for talks on topics in other fields, to show how interdependent all engineering lines are. The Visual Instruction Department will furnish film service and it is expected to better the showing made in the year just completed.

PAUL E. COX, Councilor.

OHIO STATE UNIVERSITY

This Student Branch held the following meetings during the past year.

March 8, 1921—Reports of American Ceramic Society Convention.

April 26, 1921—Address on The Manufacture of Pyrometric Cones, by H. B. Henderson.

May 10, 1921—Joint Meeting with Architects' Society. Talks on Merits and Faults of Terra Cotta.

May 26, 1921—Annual Ceramic Banquet. Mr. R. T. Stull, Supt., Bureau of Mines Station was toastmaster.

October 4, 1921—Election of Officers: B. E. Whitsell, Chairman; C. A. Smith, Vice-Chairman; E. E. Baldauf, Secy.-Treas.

October 25, 1921—Address on "Colloids in Clays" by Prof. G. A. Bole.

November 16, 1921—Joint Meeting with Central Ohio Section. Addresses by Col. Edward Orton, Jr., Dr. E. W. Washburn and President F. K. Pence.

December 13, 1921—Address on Synthetic Gems by Dr. W. J. McCaughey.

January 18, 1922—Address on The Development of Ceramic Art in Korea, by P. Wm. Lee.

At the time of this report there are forty-two members in good standing. The meetings are well attended and the interest all that could be asked.

ARTHUR S. WATTS, Councilor.

NEW YORK STATE SCHOOL OF CERAMICS

The New York Student Branch has been active throughout the year. Two meetings per month have been held except during the Summer vacation.

The principal address of each meeting is given by some member of the Faculty or the senior class. Very interesting talks are given by students giving reports of their summer work. Credit for these is given on their reports and consequently the student invariably makes a special effort to have something worth while.

At the meeting held October 11, 1921, the following officers were elected for the year: President, Robert Boyd; Vice-President, John McMahon; Secretary-Treasurer, Max Jordan.

The membership has increased to 76. Annual dues of 50 cents per member are assessed.

This year, the recent custom of defraying a part or all of the expense of a delegate to the Annual Meeting of the American Ceramic Society has been followed.

Immediately after the Annual Meeting of the parent society, the New York Student Branch entertains the Ceramic Guild, which is an organization of the Art Department of the New York State School of Ceramics. At this time, all members in attendance at the Annual Meeting give an account of the same. Preparations are already under way for this meeting which is the big event of the year for the New York Student Branch.

J. B. SHAW, Councilor.

PUBLICATIONS OF THE AMERICAN CERAMIC SOCIETY

			Bound in Cloth
Annual Transactions			
Vol. I	1899	110 pages	$4.75
Vol. II	1900	278 pages	in complete set only
Vol. III	1901	238 pages	$4.75
Vol. IV	1902	300 pages	$5.50
Vol. V	1903	420 pages	out of print
Vol. VI	1904	278 pages	$6.50
Vol. VII	1905	454 pages	$6.50
Vol. VIII	1906	411 pages	$6.50
Vol. IX	1907	808 pages	out of print
Vol. X	1908	582 pages	in complete set only
Vol. XI	1909	632 pages	$6.50
Vol. XII	1910	882 pages	out of print
Vol. XIII	1911	837 pages	$6.50
Vol. XIV	1912	888 pages	in complete set only
Vol. XV	1913	747 pages	$8.00
Vol. XVI	1914	611 pages	$8.00
Vol XVII	1915	815 pages	$8.00
Vol. XVIII	1916	947 pages	$8.00
Vol. XIX	1917	707 pages	out of print
Journal			
Vol. I	1918	892 pages	$6.00
Vol. II	1919	1030 pages	$6.00
Vol. III	1920	1016 pages	$6.00
Vol. IV	1921	1050 pages	$8.00

A complete set of the Transactions, minus Vols. V, IX, XII, and XIX, which are out of print, may be purchased at.....$150.00

(Second-hand copies of Vols. V, IX, XII and XIX, are sometimes available. Orders for these should be filed with the Secretary.)

To members of the Society a reduction of 40% will be made from the above prices. Members cannot purchase more than one copy of each volume at members' rate.

The Society has also published the following books, which will be sold net, at the prices listed, to the public and members alike:

The Collected Writings of Dr. Hermann August Seger, Volume I, (a) Treatises of a general scientific nature. (b) Essays relating to Brick and Terra Cotta, Earthenware and Stoneware, and Refractory Wares. 552 pages. Bound in cloth, $7.50

The Collected Writing of Dr. Hermann August Seger, Volume II. (a) Essays on White Ware and Porcelain. (b) Travels

Letters and Polemics. (c) Uncompleted works and extracts from the archives of the Royal Factory. 605 pages. Bound in cloth $7.50

A Bibliography of Clays and the Ceramic Arts, by Dr. John C. Branner, 1906. 451 pages. Bound in cloth. Contains 6027 titles of works on Ceramic subjects..... $2.00

Collective Index to the Transactions of the American Ceramic Society, compiled by E. J. Crane..... $1.50

The above publications can be obtained of the Secretary and will be shipped at the consignee's expense by express or parcels post to any address on receipt of the price. To all who purchase a complete set of the Transactions, a copy of the Branner Bibliography is given free. Make all checks or money orders payable to The American Ceramic Society.

PUBLIC LIBRARIES WHERE PUBLICATIONS OF THE AMERICAN CERAMIC SOCIETY MAY BE FOUND

Alfred University Library, Alfred, N. Y.
Birmingham Public Library, Birmingham, Ala.
Carnegie Library, Pittsburgh, Pa.
Carnegie Free Library of Allegheny, Pittsburgh, Pa.
Cincinnati Public Library, Cincinnati, Ohio.
Cleveland Public Library, Cleveland, Ohio.
Columbia University Library, New York City.
Cornell University Library, Ithaca, N. Y.
John Crerar Library, Chicago, Ill.
Detroit Public Library, Detroit, Mich.
Free Library, Philadelphia, Pa.
Grosvenor Public Library, Buffalo, N. Y.
Hackley Public Library, Muskegon, Mich.
Hall of the Franklin Institute, Philadelphia, Pa.
Iowa State College Library, Ames, Iowa.
James Jerome Hill Reference Library, St. Paul, Minn.
Johns Hopkins University Library, Baltimore, Md.
Library of Congress, Washington, D. C.
Los Angeles Public Library, Los Angeles, Cal.
Massachusetts Institute of Technology, Boston, Mass.
Metropolitan Museum of Art, New York City.
Missouri School of Mines, Rolla, Mo.
New Jersey Ceramic Research Station, New Brunswick, N. J.
Newark Free Public Library, Newark, N. J.
New York Public Library, New York City.
New York State Library, Albany, N. Y.
New York State School of Ceramics, Alfred, N. Y.
Ohio State University, Columbus, Ohio.
Princeton University Library, Princeton, N. J.
Providence Public Library, Providence, R. I.
Purdue University Library, LaFayette, Ind.
Spokane Public Library, Spokane, Wash.
Syracuse Public Library, Syracuse, N. Y.
St. Louis Mercantile Library, St. Louis, Mo.
St. Louis Public Library, St. Louis, Mo.
Toledo Public Library, Toledo, Ohio.
Trenton Free Public Library, Trenton, N. J.
United States Patent Office, Washington, D. C
University of California, Berkeley, Cal.

University of Colorado, Boulder, Colo.
University of Idaho, Moscow, Idaho.
University of Illinois, Urbana, Ill.
University of Iowa, Iowa City, Iowa.
University of Michigan, Ann Arbor, Mich.
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University of Utah, Salt Lake City, Utah.
University of Washington, Seattle, Wash.
University of Wisconsin, Madison, Wis.
Worcester Free Public Library, Worcester, Mass.

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Brunswick Technical School, Brunswick, Australia
Bureau of Science, Manila, P. I.
Chemical Society, London, England.
Library, Pall Mall, Hanley, England.
McGill University Library, Montreal, Canada.
Mudie's Select Library, London, England.
New South Wales Public Library, Sydney, Australia.
Tohoku Imperial University Library, Sendai, Japan.
University of Toronto Library, Toronto, Canada.
Victoria Library, Melbourne, Australia.

REGULATIONS GOVERNING THE SUBMISSION OF PAPERS, DISCUSSIONS AND REPORT

I

Type of Contributions which are Acceptable for Publication

Papers and discussions upon any topic within the field of Ceramics, embracing the non-metallic mineral industries such as the clay, glass, cement, enamelling, mortar material, and refractory material industries, and others of allied nature, especially papers embodying researches of a scientific or technical nature, papers discussing industrial or engineering practice, and papers embodying historical, economic, general and polemical discussions.

II

Reasons Which Render Contributions In-acceptable for Publication

(a) The subject matter does not fall within the Society's activities.

(b) The advertising character is too strongly in evidence, over weighing its possible technical or scientific value.

(c) The author dogmatically attacks well established theories or makes sweeping generalizations without producing adequate reasons for so doing.

(d) The contribution is substantially a duplication of matter previously published.

(e) The treatment of the subject is seriously defective as to continuity of thought and clearness of expression.

(f) The contribution seems likely to do injury to commercial or other interests, or seems to be written with malicious intent.

The Publication Committee reserves the right to reject papers upon grounds other than those stated.

III

Submission of Contributions

Titles of papers, to insure appearance in the programme of a meeting of the Society, should be in the hands of the Secretary as early as possible. To insure proper classification of papers in the programme, and the allottment of proper time for presentation, an abstract or outline is necessary, and should be furnished with the title, and in any case, not less than thirty days in advance of the meeting.

Submission of the text of all contributions, with illustrative material, should be made to the Secretary at the meeting where they are presented. In all cases, the matter must be submitted within thirty days subsequent to the meeting, and matter not submitted by this time may forfeit its place in the publication.

IV

Ownership

All contributions of whatever sort become the property of the Society upon presentation at a meeting of the Society, either in person, by proxy, or by title. The Publication Committee may, for sufficient reason, permit the withdrawal of a paper by the author, but request for such withdrawal must be made not more than thirty days subsequent to the meeting at which it was presented.

Under no circumstances has any author of a paper or discussion which has become the property of the Society, or any member of the Society who is in possession of an unpublished paper or discussion belonging to the Society, the right to submit the contribution to the daily or technical press for publication, or to divulge any part of its contents in any public way.

V

Form of Contributions

The following suggestions are for the assistance of members in preparing contributions, as well as to save the necessity of extended revision of the Editor:

Manuscript

(a) The title of the paper and the author's name should be at the top of the first page, and not upon a separate page.

(b) The pages of the manuscript should be numbered and written upon one side only.

(c) All manuscript should be typewritten if possible, using double space to facilitate editing.

(d) The original and not the carbon copy should be given to the Society.

(e) Ample margins of one and one-half inches all around, should be left.

(f) Slang, trade vernacular, or local expressions not in general use in an industry should not be used. If an unusual technical term must be employed, it should be defined at the point of its first use in the article. Abbreviations or symbols, excepting those which have attained general recognition in technical treatises, should not be used.

For instance, the symbols & for and, % for per cent, " for inches or seconds, in the text.

(g) The chief references germane to their topics should be submitted by all authors in the form of foot notes. References should be indicated in the text by superior figures, and these figures should be consecutive from beginning to end of the article, and not for each page.

(h) The title of the paper discussed and the name of the person contributing the discussion should be at the top of the first page of the discussion. All suggestions applying to original manuscripts apply to discussions.

Illustrations

(a) Every illustration, of whatever sort, should be plainly marked on the margin or back, with the author's name, the title of the paper, and the number of the illustration corresponding to its place in the text. If marked upon the back, the marks should not be made so heavy as to show through and interfere with reproduction.

(b) All illustration should conform to a 2x3 ratio where possible, and the short dimension should preferably be made the vertical one. The exact size of the illustration is not important so long as it is clear and sharp, and need not be reduced more than two diameters in reproduction. A reduction of one-third gives the best results.

(c) If photographs are furnished, glossy prints showing the maximum detail are preferred. If drawings are furnished, the lines should be made plain and rather heavy.

If curve sheets are furnished, too many curves should not be put upon one sheet, and all intersecting curves should be made so plain that there can be no question about the continuity of each.

The Society will not ordinarily reproduce plates in colors. Where such are desired, they must be made the subject of special arrangement with the Publication Committee.

Galley Proof

Galley proof is sent to the author for correction of typographical errors or omissions. It is not sent out for text revision. The revision of an article, once set into type, will be permitted only when it can be shown that the copy was in error, through no fault of the author. Galley proof of discussions will not be furnished.

REGULATIONS GOVERNING THE EDITING AND PUBLISHING OF PAPERS.

VI

General Duties of Editor

The Editor shall prepare for publication all papers, discussions and reports presented to the Society. Unless with the previously obtained consent of the author, he shall not change the expressions of the author, except to correct tautology, ambiguity or grammatical errors. His jurisdiction shall be over form and not substance of matter presented for publication.

He shall not have the power to eliminate or omit from publication in the Transactions, any paper or discussion, or essential part thereof, yet it shall be his duty to submit to the Publication Committee any paper or discussion that in his opinion is unsuitable for publication by the Society, and he shall be governed by the action of the committee in the matter.

It shall be the duty of the Editor when possible, to elicit further discussion of papers which have been discussed inadequately or read by title.

VII

Titles, Degrees and Distinctions

It shall be the duty of the Editor to maintain uniformity with regard to titles, degrees and distinctions of members. Such titles and degrees will be printed in official membership roll, but not in connection with the authorship of papers, discussions and reports, or in the text where allusion is made to a member's name.

Reference to business affiliations will not be permitted in connection with an author's name at the head of a paper. A foot note indicating that the work of an author has been done under the auspices of an industrial, scientific, educational, or other organization, or under the patronage of an individual may be inserted if desired.

VIII

Form of Papers

It shall be the duty of the Editor to maintain a standard practice regarding the form of the publication, as to typography, arrangement of headings, subheadings, titles of tables, illustrations and similar matters.

Property of
Research Division

IX

Order of Procedure in Publications

(a) A stenographic report will be made of all the proceedings of the Society at its annual meeting, or other meetings of literary character.

(b) The Editor will send galley proof of the original contribution, together with the stenographic report of the discussion upon it, to the author and to each person who entered into the discussion.

(c) Each discussor will have the privilege of preparing a written discussion, in lieu of the oral discussion which he made at the meeting. The stenographic report of the discussion as held at the meeting will not be printed. Others who enter a discussion subsequent to a meeting will receive the same treatment as those originally entering it.

(d) A time limit of three weeks from the date of mailing the article and the stenographic report of the discussion upon it, will be given for the return of written discussions to the Editor's office, by those who desire to participate. In special cases, this time limit may be extended by the Publication Committee.

(e) The original author will have the opportunity of closing the discussion.

Preparation of Abstracts

Every article in this Journal is to be preceded by an abstract prepared by the author and submitted by him with the manuscript. The abstract is intended to serve as an aid to the reader by furnishing an index and brief summary or preliminary survey of the contents of the article; it should be suitable for reprinting in an abstract journal so as to make a reabstracting of the article unnecessary. The abstract should, therefore, summarize all new information completely and precisely. Furthermore, in order to enable a reader to tell at a glance what the article is about and to enable an efficient index of its subject matter to be readily prepared, the abstract should contain a set of subtitles which together form a complete and precise index of the information contained in the article. This requires at least one and often several subtitles even for a short abstract.

In the preparation of abstracts, authors should be guided by the following rules, which are illustrated by the abstracts in this Journal for February and March, 1921.* The new information contained in an

*The rules were prepared by the Research Information Service of the National Research Council. The Society is indebted to Dr. G. S. Fulcher of the Corning Glass Works (formerly with the National Research Council) for the rules and the illustraitve abstracts.

article should first be determined by a careful analysis; then the subtitles should be formulated; and finally the text should be written and checked.

Rules

1. Material not new need not be analyzed or described in detail; a valuable summary of a previous work, however, should be noted with a statement indicating its nature and scope.

2. The subtitles should together include all the new information; that is every measurement, observation, method, improvement, suggestion and theory which is presented by the author as new and of value in itself.

3. Each subtitle should describe the corresponding information so precisely that the chance of any investigator being misled into thinking the article contains the particular information he desires when it does not, or vice versa, may be small. Such a title as "A note on blue glass," for example, is evidently too indefinite a description of information regarding "Absorption spectra of glass containing various amounts of copper-cobalt and chromium-cobalt." General subtitles, such as "Purpose" and "Results" should not be employed as they do not help to describe the specific information given in the article.

4. The text should summarize the author's conclusions and should transcribe numerical results of general interest, including those that might be looked for in a table of physical and chemical constants, with an indication of the accuracy of each. It should give all the information that anyone, not a specialist in the particular field involved, might care to have in his note book.

5. The text should be divided into as many paragraphs as there are distinct subjects concerning which information is given, but no more than necessary. All parts of subtitles may be scattered through the text but the subject of each paragraph, however short, must be indicated at the beginning.

6. Complete sentences should be used except in the case of subtitles. The abstract should be made as readable as the necessary brevity will permit.

7. The ms. of all abstracts must be typewritten and double or triple spaced.

Constitution and By-Laws

CONSTITUTION

ARTICLE I

(1) This Society shall be known as the American Ceramic Society.

(2) The object of the Society is to advance the ceramic arts and sciences by meetings for the reading and discussion of papers,

ARTICLE II

Membership

(1) The Society shall consist of Honorary, Active, Associate, Corporation and Industrial Association Members.

(2) Honorary Members must be persons of professional eminence, elected in recognition of their achievements in ceramic art or science. Their number shall not exceed ten.

(3) An Honorary Member shall be nominated by at least ten Active Members and unanimously approved by the Board of Trustees. Their nomination shall be placed before the Society at an annual meeting, and to be elected they must receive the affirmative vote of at least ninety per cent of those voting, by letter ballot, at the next succeeding annual election.

(4) Active Members must be persons competent to fill responsible positions in ceramics. Only Associate Members shall be eligible to election as Active Members and such election shall occur only in recognition of attainments or of services in the science, technology, or art of the ceramic or allied industries.

(5) The Board of Trustees shall at each regular meeting advance to Active Membership all Associate Members whose activity in the Society or whose prominence in the ceramic industries, in the opinion of a majority of the Board of Trustees, merits such recognition. Any Active Member may nominate in writing Associates for Active Membership, accompanying same by a written statement of the qualifications of each candidate, and the Board of Trustees shall act on such recommendations at the next regular meeting of the Society.

(6) Associate Members must be persons interested in the ceramic or allied industries.

(7) Corporation Members must be persons, firms, or corporations who, being interested in the Society, make such financial contribu-

tions for its support as are prescribed in Article III. Their membership shall become operative on payment of dues as prescribed in Article III.

(8) Industrial Association Members must be organized groups of manufacturers, who being interested in the advancement of ceramic arts and sciences shall make, for this purpose, such financial contributions as are prescribed in Article III.

(9) All Honorary Members, Active Members, Associate Members, Corporation Members, and Industrial Association Members shall be equally entitled to the privileges of membership, except that only Active Members and one representative of each Corporation Member shall be entitled to vote. Such representative shall be officially designated by the person, firm, or corporation represented. Only Active Members shall be entitled to hold office. The roster of each grade of membership shall be printed separatly in at last one publication issued by the Society annually.

(10) Any person may be expelled from any grade of the membership of the Society if charges signed by five or more Active Members be filed against him or her, and if the Board of Trustees examine into and sustain said charges by a majority vote. Such person, however, shall be first notified of the charges against him and be given a reasonable time to appear before the Board of Trustees or to present a written defense, before final action is taken.

ARTICLE III

Dues

(1) Honorary Members shall be exempt from all fees and dues.

(2) The annual dues for Active and Associate Members shall be fixed by the Board of Trustees but shall not exceed ten dollars, six dollars of which shall be a subscription to the **Journal of the American Ceramic Society.**

(3) Corporation Members shall pay such annual dues as are fixed by the Board of Trustees but these shall not be less than twenty-five dollars, six dollars of which shall be a subscription to the **Journal of the American Ceramic Society.** The privileges of membership shall begin upon payment of the annual dues.

(4) Industrial Association Members shall pay such annual dues, in monthly installments or single payment, as shall be agreed upon by the Association and the Board of Trustees, but such dues shall not be less than $480.00 annually.

ARTICLE IV

Officers

(1) The affairs of the Society shall be managed by a Board of Trustees consisting of the President, the Vice-President, the Treasurer, the retiring President, his immediate predecessor, and three Trustees. The President, the Vice-President and the Treasurer shall be elected to serve one year. The Trustees shall be elected to serve three years, one Trustee being elected each year.

(2) The President shall have general supervision of the affairs of the Society under the direction of the Board of Trustees and shall perform such other duties as pertain to his office.

(3) He shall countersign the checks drawn by the Treasurer when such drafts are known by him to be proper and duly authorized by the Board of Trustees.

(4) A Secretary shall be appointed by the Board of Trustees for a term of not more than two years.

(5) The Secretary shall see that all moneys due the Society are carefully collected and transferred to the custody of the Treasurer. He shall carefully scrutinize all expenditures and use his best endeavors to secure economy in the administration of the Society. He shall personally investigate and certify the accuracy of all bills or vouchers on which money is to be paid. He shall have charge of the books of accounts of the Society and shall furnish monthly to the Board of Trustees a statement of monthly balances. He shall present annually to the Board of Trustees a balance sheet of his books as of the 31st of December and shall furnish from time to time such other statements as may be required of him.

(6) He shall conduct the correspondence of the Society and keep full record of the same. He shall transmit promptly to the Board of Trustees for their consideration all communications not of routine nature. He shall cause to be published in the Journal the results of all balloting on the business of the Society unless otherwise ordered by the Board of Trustees. He shall perform all other duties which may from time to time be assigned to him by the Board of Trustees.

(7) The Secretary may be paid a salary to be determined by the Board of Trustees.

(8) The Secretary shall furnish a suitable bond for the satisfactory performance of his duties which shall be held in the custody of the President.

(9) The Treasurer shall receive all moneys due the Society and deposit the same in the name of the Society in a National

Bank designated by the Treasurer and approved by the Board of Trustees. He shall invest all funds not needed for current disbursements as shall be ordered by the Board of Trustees. He shall pay all bills by draft when certified by the Secretary or as ordered by the Board of Trustees. He shall furnish a satisfactory bond for the proper performance of his duties, which shall be held in the custody of the President.

(10) All securities belonging to the Society shall be held in the custody of the Treasurer.

(11) The accounts of the Secretary and of the Treasurer shall be audited before each annual meeting by a certified public accountant or some other competent person designated by the Board of Trustees.

(12) A vacancy in any office shall be filled by appointment by the Board of Trustees but the new incumbent shall not thereby be rendered ineligible for re-election to the same office at the next annual meting. On the failure of any officer or any member of a committee to execute his duties within a reasonable time, the Board of Trustees, after duly warning such person, may declare the office vacant and appoint a new incumbent.

(13) A majority of the Board of Trustees shall constitute a quorum, but the Board of Trustees shall be permitted to carry on such business as they may desire by letter.

ARTICLE V

Elections

The nominating committee shall be composed of the last two ex-presidents and one representative elected by each Division and Local Section who shall select a ticket for the offices of President, Vice-President, Treasurer and one Trustee. The Secretary of the Society shall be chairman (without vote.) At least ninety days before the annual meeting the Secretary shall send the names of the nominees to each voting member. Any ten members, at least five of whom shall be Active, may constitute a self-appointed nominating committee and present the names of any nominees to the Secretary, provided this is done at least thirty days before the annual meeting. The names of all nominees, provided their assent has been obtained before nomination, shall be placed upon the ballot in alphabetical order and shall be mailed to each voting member, not in arrears, at least twenty days before the annual meeting. The voting shall be confined to the names appearing on this ballot. The ballot shall be enclosed in an envelope on which there shall be no mark of identification other than the word "Ballot." This envelope shall be enclosed in another envelope for mailing, addressed to the Secretary, upon the back of which the voter

shall endorse his name. The envelopes and ballots shall be opened in the presence of three scrutineers appointed by the President, who will report the result of the election at the last session of the annual meeting. A plurality of affirmative votes cast shall elect.

ARTICLE VI

Standing Committees

(1) The following Standing Committees shall be appointed annually by the Board of Trustees:

1. Rules
2. Publications
3. Membership
4. Standards
5. Sections and Divisions
6. Papers and Programs
7. Research
8. Geological Surveys
9. Data
10. A Co-ordinating Service Council.

The chairman of each committee shall be appointed by the Board of Trustees.

(2) The Committee on Rules shall consist of five members in addition to the chairmen of the Rules Committees of the divisions having such committees. It shall receive all recommendations relating to changes of Constitution and By-Laws and shall report upon the same to the Secretary for transmission to the Society. It shall have power to propose changes in the Rules of the Society.

(3) The Committee on Publications shall consist of the Editor and four members. The duties of the Editor and Committee on Publications are defined under Article X on Publications.

(4) The Committee on Membership shall consist of at least five members in addition to the chairmen of Membership Committees of the divisions having such committees, and shall have power to appoint sub-committees. Its function shall be to undertake systematically the enlargement of the membership of the Society amongst those interested in the ceramic and allied industries.

(5) The Committee on Standards shall consist of a chairman appointed by the Board of Trustees and topic groups as follows:

Group of Definitions, consisting of three members appointed by the Board of Trustees.

Group of Raw Material Specifications, consisting of three members appointed by the Board of Trustees.

Group on Standardization of Tests, consisting of one member elected by each Division.

Group of Standardization of Products, consisting of one member elected by each Division.

(6) The divisional Standardization Committees shall be appointed in and by their respective divisions. Their function shall be the preparation of tests and specifications for the materials and products of their respective branches of the ceramic industry. Each shall be responsible to its division, but all reports, resolutions, or recommendations that are to be printed or generally distributed shall be approved by the Committee on Standards before publication.

(7) The function of the Committee on Standards shall be to prepare or have prepared tests and specifications for ceramic materials and products and to submit to the Board of Trustees written reports, resolutions and recommendations relating thereto. The Committee may report at any regular meeting of the Society. For adoption, these reports, resolutions, and recommendations must be submitted in printed form to the members of the Society at least six months before a vote may be taken, during which time any amendments, changes, or corrections, suggested by any member may, with the approval of the Committee, be incorporated. The reports, resolutions, and recommendations as amended shall then be submitted by letter ballot to the voting members. A two-thirds vote shall be required for adoption, and the polls shall close 60 days after distribution of the ballot.

(8) The Committee on Sections and Divisions shall consist of five members in addition to the chairmen of the Divisions. Its duties shall be to promote the organization and welfare of Local Sections, Student Branches, and Divisions.

(9) The Committee on Papers and Programs shall consist of the secretaries of the Divisions, the Secretary of the Society, and such other persons as the Board of Trustees may deem advisable. Its duties shall be to procure papers and discussions for the meetings and publications of the Society. The Committee may require an abstract of any paper submitted before placing it upon a program.

(10) The Committee on Research shall consist of a chairman and three members appointed by the Board of Trustees, and one member elected by each Division. Its duties shall be to organize and encourage scientific investigations pertaining to the ceramic and related industries, especially those investigations which will stimulate the development of our national industries and resources. It shall be empowered to co-operate with similar committees of other scientific societies and with Government bureaus.

(11) The Committee on Geological Surveys will co-operate with National and State Geological Surveys and Associations in planning laboratory and plant investigations instituted by them, and interpreting data. This committee shall consist of a chairman and four members appointed by the Board.

(12) The Committee on Data shall arrange symposiums and prepare for publication monographs, bibliographies, statistics, etc. This committee shall consist of a chairman appointed by the Board of Trustees and one member elected by each Division.

(13) The Co-ordinating Service Council shall consist of the General Secretary, ex-officio chairman, and the Chairmen of the Committees on Research, Standards, Geological Surveys, and Data. The Council shall have general supervision of the work of these committees, for the purpose of co-ordinating other organizations on ceramic topics and problems.

ARTICLE VII

Divisions

(1) Groups to be known as Divisions of the Society and to be organized from members of the Society may be authorized by the Board of Trustees for stimulating the growth and development of the Society, when such action shall seem wise and expedient. Only bona fide members of the Society are entitled to affiliate with and participate in the activities of such Divisions, but Divisions which, prior to August, 1920, have enrolled persons who are not members of the Society, may retain such persons as members of the Division. A member of the Society may enroll in any Division in which he is interested.

(2) The affairs of a Division shall be managed by a Chairman, a Secretary-Treasurer, and such other officers as the division may deem necessary. The officers of the Division shall be elected annually by ballot at the last session of the Division held during the annual meeting of the Society and shall take office at the close of the meeting at which they are elected. All members of a Division are entitled to vote. The officers shall hold office for one year or until their successors are elected.

ARTICLE VIII

Local Sections

(1) Local Sections, each carrying some distinguishing title prefixed to the words "Section of the American Ceramic Society," may be authorized by the Society.

(2) The purposes of such sections shall be to strengthen and extend the work of the Society, as defined in Section I of its Rules,

by more frequent meetings in local centers than are possible to the Society as a whole, and by bringing the benefits of the work to persons who would not otherwise be reached.

(3) Application for permission to form a Local Section must be in writing and signed by not less than ten members of the Society in good standing, residing in the general locality where the Section is to be formed, of whom one at least shall be an Active Member. To be considered at any given meeting an application must be filed with the Secretary at least thirty days prior to the date of the meeting and notice that the application is pending must appear in the program of the meeting. To be granted, the application must receive the affirmative vote of two-thirds of those present. In event of affirmative action the Society will issue a charter to the applicants, authorizing them to form a Section under the name proposed. Charters for Local Sections may be temporarily suspended by the Board of Trustees for cause, but no charter can be permanently rescinded except by vote of two-thirds of those present at a regular meeting of the Society, after due publication in the program of the meeting that the matter is pending.

(4) Local Sections shall have power to make their own rules and by-laws except that they shall not pass any rule or by-law which is in conflict with the Rules of the Society.

(5) The officers of Local Sections shall be a Chairman, a Secretary, a Councilor, and such others as the Sections may prescribe. The duties of the Chairman and Secretary shall be such as usually pertain to those offices. The Councilor shall be an Active Member of the Society. He shall be elected by the Local Section and it shall be his duty to advise the Section in all matters pertaining to its relations with the Society and to make an annual report to the Society regarding the work and status of the Section. The names of the Chairman, Secretary, and Councilor of each Section shall appear in the roster of the Society.

ARTICLE IX

Student Branches

(1) Student Branches, each carrying some distinguishing title prefixed to the words "Student Branch of the American Ceramic Society," may be established in institutions in which regular courses of instruction in ceramics are maintained.

(2) The purpose of such Student Branches shall be to strengthen and extend the work of the Society, as defined in Section I of the Rules, by enlisting the interest and support of students in ceramics while still in school and by stimulating the spirit of ceramic research among them.

(3) Application to form a Student Branch in any institution must be in writing, signed by not less than five regularly enrolled students in good standing and endorsed by two or more members of the Society. The application must be filed and acted upon as provided for Local Sections in Section IX, and may be suspended or revoked for cause in the same manner.

(4) Student Branches shall have power to make their own rules and by-laws, except that they shall not pass any rule or by-law in conflict with the Rules of the Society.

(5) The officers of Student Branches shall be a Chairman, a Secretary, a Councilor, and such others as the Student Branch may prescribe. The Chairman and Secretary shall be elected by the Student Branch and their duties shall be such as usually pertain to those offices. The Councilor shall be an Active Member of the Society, appointed by the Board of Trustees to act in this capacity to the Student Branch. The duties of the Councilor shall be to advise the Student Branch in all matters pertaining to its relations to the Society and to make an annual report to the Society regarding the work and status of the Student Branch. The names of the Chairman, Secretary, and Councilor of each Student Branch shall appear in the roster of the Society.

ARTICLE X

Publications

(1) The Board of Trustees may employ, at a suitable compensation, an editor of the publications of the Society.

(2) The Committee on Publications shall have general supervision of the publications of the Society and of contracts and expenditures connected therewith, subject to the approval of the Board of Trustees.

(3) In the consideration of papers offered for presentation or publication those papers containing matter readily found elsewhere, those specially advocating personal interests, those carelessly prepared or controverting established facts, and those purely speculative or foreign to the purpose of the Society shall be rejected. The Committee on Publications shall determine which papers shall be printed. The Committee may return a paper to the writer for correction and emendation and may call to its aid one or more members of special experience relating to the subject treated, either to advise on the paper or to discuss it.

(4) All papers and discussions presented before the general session of the Society shall become the property of the Society and their publication or other disposition shall be in the hands of the Committee on Publications.

No paper or discussion presented before a Division or Local Section shall be offered for publication elsewhere until the Committee on Publications shall have had the option of accepting the same for use in the **Journal of the American Ceramic Society.**

(5) The Committee on Publications shall provide for the publication of a monthly perodical entitled the **Journal of the American Ceramic Society,** the subscription price of which shall be six dollars to members and eight dollars to non-members.

(6) One copy of each issue of the paper-bound edition of the Journal shall be sent prepaid to each member of the Society not in arrears. No member shall be furnished with more than one copy of each issue free for any single year. A member may be permitted to complete by purchase one file of the publications of the Society at less than the current commercial rate, the amount to be fixed by the Board of Trustees and to be called the member's rate.

(7) The Secretary shall have the custody of all publications of the Society, shall keep them safely stored and insured, and shall sell them to the public at prices which shall be fixed by the Board of Trustees. The Board of Trustees shall also, from time to time, fix the price of the volumes remaining unsold and shall have authority to refuse to sell the back volumes of the Transactions and Journals except in complete sets, at such time as the quantity remaining of any number becomes so small as in their judgment to warrant such action.

(8) The Editor shall request the author of each article appearing in the Journal of the Society to fill out and sign, within a definite time limit, a form, specifying the number of reprints of said article, if any, which he desires. This form shall contain a table from which can be computed the approximate cost at which any reprints will be furnished. In event that the expense of furnishing the desired number of reprints is large, the Board of Trustees may require the author to pay part or all of the cost involved before the publication of the reprints is begun. On receipt of such signed order within the time limit set the Editor shall cause to have printed the desired number of copies. If the author makes no reply or replies after the time limit has expired then the Society will not be responsible for the publication of any reprints of the article in question except at the usual market price for the printing of new matter.

(9) No one shall have the right to demand the publication of an article independent of the discussion which accompanied it and no one having taken part in a discussion upon an article shall be entitled to order reprints of the discussion separately and apart from the article itself.

(10) The Society is not, as a body, responsible for the statement of facts or opinions expressed by individuals in its publications.

ARTICLE XI

Parliamentary Standard

Roberts' "Rules of Order" shall be the parliamentary standard on all points not covered by these rules.

ARTICLE XII

Amendments

Any proposed amendment to this Constitution must be presented in writing at a regular meeting of the Society and, if approved by the Committee on Rules or by any ten Active Members, must be printed on a ballot and sent out not earlier than thirty nor later than sixty days after the adjournment of the meeting at which the amendment was presented. If the said letter ballot shows an affirmative vote of not less than two-thirds of the total vote cast within fourteen days of the date of mailing, then the same shall be declared carried and shall at once become effective.

ARTICLE XIII

By-Laws

The Society shall make such By-Laws not in conflict with this Constitution as may be necessary for the proper government of the Society. Such By-Laws shall become operative when approved by the Board of Trustees and confirmed by two-thirds affirmative vote of the members voting at any annual meeting.

BY-LAWS

SECTION I

Meetings

(1) The annual meeting shall take place on the first Monday in February, or as soon thereafter as can be arranged, at such place as the Board of Trustees may decide, at which time reports shall be made by the Board of Trustees, Treasurer, and scrutineers of election, and the accounts of the Treasurer shall be audited by a committee of three appointed by the President. Twenty-five Active Members shall constitute a quorum at any regular meeting and a majority shall rule unless otherwise specified.

(2) Other meetings may be held at such times and places during the year as the Board of Trustees may decide, but at least twenty days notice shall be given of any meeting.

(3) The President shall appoint at the annual meeting a committee of five, to be known as the Summer Meeting Committee, whose duty it shall be to arrange for a summer excursion meeting at some suitable point. They shall then select a local committee which shall have charge of the details of the meeting. The expenses of the Summer Meeting Committee in arranging the program of visits and for printing, rooms, and facilities for meetings shall be borne by the Society.

SECTION II

(1) At the Annual Meeting of the Society, the order of business shall be as follows:

1. President's address.
2. Reading of minutes of last meeting.
3. Reports of the Board of Trustees and Treasurer.
4. Old business
5. New business.
6. Reading of papers.
7. Announcement of election of officers, Honorary and Active Members.
8. Installation of officers.
9. Appointment of committees.
10. Adjournment.

SECTION III

Only Active Members shall be eligible to election as officers.

SECTION IV

Any members in arrears for over one year may be suspended from membership by the Board of Trustees until such arrears are paid. Active Members in arrears are not eligible to vote. The annual dues of Active and Associate Members are payable on January first.

SECTION V

The Secretary of each Division, Local Section, and Student Branch shall report to the Secretary of the Society the names of its officers and Standing Committee Chairmen within three weeks of their election or appointment and shall also furnish the Secretary with a complete list of its membership on April 1st of each year.

SECTION VI

(1) Any person interested in the ceramic and allied industries is eligible to membership in a local Section.

(2) Local Sections shall have power to fix their own dues or

assessments, such dues or assessments being in addition to and independent of the regular dues and assessments of the Society upon its members. No Section shall have authority to incur debt in the name of the Society or for which the Society may become liable.

SECTION VII

(1) Membership in a Student Branch shall be limited to the instructional force and regularly enrolled students of schools in which branches are located, subject to the rules of the school concerned governing outside activities of students.

(2) Student Branches shall have power to fix their own dues and assessments and, as such, shall pay no dues to the Society. No Student Branch shall have authority to incur debt in the name of the Society or for which the Society may become liable.

(3) Members of a Student Branch as such shall pay no dues to the Society but upon depositing a certificate of good standing from their Secretary, may purchase from the Society its publications at the same rate as Associate Members of the Society. This privilege shall cease when the student's connection with the school ceases, but members of a student Branch, upon leaving school, may at once become Associate Members of the Society by depositing their certificates, making proper application, and paying the regular dues.

SECTION VII

(1) The Committee on Publications shall acknowledge to the author acceptance of all contributions submitted to it and in case of rejected contributions the original copy shall be returned to the author.

(2) Contributions remaining in possession of the Committee on Publications for more than one year without publication shall cease to be the property of the Society and shall revert to the author.

SECTION VIII

(1) The Board of Trustees shall appoint such special committees as may seem necessary for the proper conduct of the affairs of the Society.

(2) All Special Co-operative Committees shall be appointed only on nomination of the Co-ordinating Service Council.

SECTION IX

The Board of Trustees shall have power to make any rules not inconsistent with the Constitution and By-Laws for the conduct of its business.

IN MEMORIAM

M. B. CHENEY

S. C. LINBARGER

THOS. L. STRONG

GEORGE W. THOMAS

C. W. WILLIAMS

MEMBERSHIP LIST

* Active Members.
† Honorary Members.
; Life Members.

Abbott, Harold W., Supt., Carbon Dvision, Stackpole Carbon Co., St. Marys, Pa.
Abrams, Duff A., Lewis Institute, Chicago, Ill.
Acheson, A. E., Gen. Mgr., J. H. Gautier & Co., Jersey City, N. J.
Acheson, Edward G., 35 West 42nd St., New York City, Pres., The Acheson Co.
Adams, C. C., Latrobe, Pa., Sec.-Treas., Conemaugh Iron Works Co.
Adams, Lewis A., Mansfield, Ohio, Supt., Mansfield Vitreous Enameling Co.
Adams, Samuel P., 29 S. La Salle St., Chicago, Ill., Dist. Rep., Ashland Fire Brick Co.
Adderley, James R., 50 Lower Potter St., Brierley Hill, S. Staffs, England, Chemist, E. J. & J. Pearson Ltd. Firebrick Works.
***Agge, Franklin**, Buffalo, N. Y., Mgr., Republic Metalware Co.
Ahlswede, R. B., 1406 N. Spring St., Los Angeles, Cal., Sec., California Metal Enameling Co.
Ahrens, Robert S., St. Paul, Minn., Seeger Refrigerator Co.
Aichele, Albert E., 524 Orchard Ave., Cambridge, Ohio.
***Albery, D. F.**, 2525 Clybourn Ave., Chicago, Ill., Northwestern Terra Cotta Co.
Albright, Emmet C., 245 Ohio Ave., Sebring, Ohio, Pres., The Gem Clay Forming Co.
Alcan, Raphael, Maurer, N. J., Local Mgr., American Encaustic Tiling Co., Ltd.
Algeo, A. M., Washington, Pa., Supt., Hazel-Atlas Glass Co.
Allcock, Francis T., 449 S. Malabar St., Huntington Park, Los Angeles, Cal., American Encaustic Tiling Co.
***Allen, F. B.**, Woodbridge, N. J., M. D. Valentine & Bro. Co.
***Allison, LeRoy W.**, 170 Roseville Ave., Newark, N. J., Adv. Mgr., Journal of the American Ceramic Society.
Amsler, Walter O., 707 Farmers Bank Bldg., Pittsburgh, Pa., Pres., Amsler Morton Co.
Anderle, Emil Jos., 132 E. Hudson Ave., Dayton, Ohio, International Clay Machinery Co.
Andersen, Olaf, Statsgeolog Mineralogisk Museum, Kristiania, Norway, Government Geologist.
Anderson, George O., Parkersburg, W. Va., Sec. and Treas., General Porcelain Co.

Anderson, John A., 299 Central St., Gardner, Mass., Electrician and Chemist, Central Gas and Oil Stove Co.

Anderson, Robert E., Morrisville, Pa., Robertson Art Tile Co.

Anthony, Wm. R., Taunton, Mass., Foreman, Enameling Dept., Weir Stove Co.

Aoki, S., Futajima, Ongagun, Fukuoka, Japan, American-Japan Sheet Glass Co.

***Applegate, D. H. Jr.**, Charleston, Staten Island, N. Y., The Kreischer Clay Products Co., Inc.

Arbenz, Fred J. A., Cambridge, Ohio.

***Arnold, Howard C.**, 4906 McPherson Ave., St. Louis, Mo.

***Ashbaugh, Chas. C.**, East Liverpool, Ohio, Sec. and Treas., West End Pottery Co.

Ashman, Alfred O., 277 Delaware Ave., Palmerton, Pa., New Jersey Zinc Co.

Auld, F. Howard, Fifth Ave. and Fifth St., Columbus, Ohio, Gen. Mgr., The D. L. Auld Co.

Aurien, George, 4070 N. Main St., St. Louis, Mo., Supt., Mississippi Glass Co.

Austin, Arthur O., 326 N. 6th St., Barberton, Ohio, Factory Mgr., Ohio Insulator Co.

Austin, G. L., Joliet, Ill., Supt., American Refractories Co.

Austin, James L., Mexico, N. Y.

Axford, Vincent, Tulane University, New Orleans, La., Newcomb Pottery.

***Ayars, E. E.**, Box 3, Danville, Ill., Supt., American Refractories Co.

***Babcock, M. G.**, 241 McKee Place, Pittsburgh, Pa., Laclede-Christy Clay Products Co.

Baccus, Mrs. Julia F., 995 Elbon Road, Cleveland Heights, Ohio.

Bach, Julius H., 2647 Montrose Ave., Chicago, Ill., Bach Brick Co.

Bachman, P. S., 92 W. Maynard Ave., Columbus, Ohio, U. S. Bureau of Mines.

***Back, Robert**, Chicago, Ill., Factory Chemist, The Wahl Co.

Bacon, Chas. C., Tacony, Philadelphia, Pa., Sec., Ross-Tacony Crucible Co.

Baggs, Arthur E., Marblehead, Mass., Mgr., Marblehead Pottery Co.

Bailar, John C., 1512 Maple St., Golden, Colo., Colorado School of Mines.

Baker, Earl B., 22 16th Ave., Columbus, Ohio, Junior Ceramic Engineer, U. S. Bureau of Mines.

Baker, G. V., (Address unknown).

Bales, Cecil E., Highland Park, Ky., Louisville Fire Brick Works.

***Balmert, Richard M.**, Box 183, Angola, N. Y., Supt., Lyth Tile Co.

***Balz, George A.**, Rahway, N. J., Mechanical Engineer.

*Bardush, J. F., Grand Rapids, Mich., Grand Rapids Refrigerator Co.
Barker, Charles E., Matawan, N. J., Atlantic Tile Mfg. Co.
Barlow, Alfred, Wilmington, Del., Supt., Golding Sons Co.
*Barnes, T. R., Mansfield, Ohio, Sec. and Gen. Mgr., Barnes Mfg. Co.
Barrett, Maurice, 17 Gledhow Ave., Leeds, England.
*Barringer, L. E., Schenectady, N. Y., Engineer of Insulations, General Electric Co.
Bartells, H. H., (Address unknown).
Barth, Victor, 128 Bridge St., Great Barrington, Mass., Enameler, Stanley Insulating Co.
Bartlett, Edward E., Sapulpa, Okla., Bartlett-Collins Glass Co.
Bartlett, John H. Jr., 2 Wood St., London, S. W. 1 England, British Furnaces, Ltd.
*Barton, G. E., 227 Pine St., Millville, N. J., Chief Chemist and Technical Expert, Whitall Tatum Co.
Bassett, Leon B., Winchendon, Mass., Asst. Sales Mgr., Baxter D. Whitney & Sons, Inc.
Bates, Charles E., Perth Amboy, N. J., National Fire Proofing Co.
*Bates, P. H., 3220 Morrison St., Chevy Chase., D. C., U. S. Bureau of Standards.
Bateson, H. A., Spekeland Rd., Edge Hill, Liverpool, England.
Bauer, James L., Middletown, Conn., Asst. Sec. and Asst. Treas., New England Enameling Co.
Bausch, Frederic E., 1105 Chemical Bldg., St. Louis, Mo., Proprietor, Fire Clay Mines.
Bautz, Robert A., Murphysboro, Ill., Isco-Bautz Co., Inc.
Beasley, H. C., Cicero, Ill., Gen. Supt., Coonley Mfg. Co.
Becker, Martin Grover, Box 542, Brookhaven, Miss., Asst. Mgr., Brookhaven Pressed Brick and Mfg. Co.
Becket, Frederick M., Niagara Falls, N. Y., Chief Metallurgist, Union Carbide Co.
Becque, Lieut. J. H., Edgewood Arsenal, Edgewood, Md.
Beebe, Daniel S., Chamber of Commerce Bldg., Chicago, Ill., Vice-Pres., Treas., and Gen. Mgr., The Vitrolite Co.
*Beecher, Milton F., Worcester, Mass., Norton Co.
Beeken, L. L., Kenova, W. Va., Jeffery-Dewitt Insulator Co.
Behrent, Leo A., 1515 Lumber Exchange Bldg., Chicago, Ill., Laboratory Assistant, Midland Terra Cotta Co.
Bell, Fred S., 1318 Wright Bldg., St. Louis, Mo., Vice-Pres., Mandle Clay Mining Co.
*Bell, M. L., 901 South Ave., Wilkinsburg, Pa., Ceramic Engineer, Carnegie Steel Co., Braddock, Pa.
*Bellamy, Harry T., Chicago, Ill., Hawthorn Plant, Western Electric Co.

Benner, Wm. J., Grand Ledge, Mich., Briggs-Michigan Clay Co.

*__Bentley, Louis L.__, Beaver Falls, Pa., Supt., Armstrong Cork Co.

Berger, William S., 1601 Woodburn Ave., Covington, Ky., Sec., Cambridge Tile Mfg. Co.

Bergman, William G., Station G, Box 6, Toledo, Ohio, Engineer and Manager, McCamic-Batchell-Bergman Co.

Bergmans, Carl, Flint, Mich., Champion Ignition Co.

Berkey, Paul L., 309 Wabash Bldg., Pittsburgh, Pa., Sec.-Treas., Plant Supt., Lava Crucible Co.

Berland, Louis, 10 Grand Rue, Villejuif, (Seine), France, Directeur de la Société Nouvelle de la Manufacture de Porcelaines de Ste. Fay l'Argentiere.

Berolzheimer, Daniel D., 1 Madison Ave., New York City, Asst. Technical Editor, The Chemical Catalog Co., Inc.

*__Berry, Charles W.__, St. Louis, Mo., Mitchell Clay Mfg. Co.

Bianchedi, Romulo, Calle Junin 1028, Buenos Aires, Argentine, Head of Piccardo y Cia's Glass Works.

Bickel, Earl A., Postville, Iowa, Assistant to Manager, Postville Clay Products Co.

Bidleman, Wm. J., Wellsville, Mo., Wellsville Fire Brick Co.

Bill, Harry, 2230 McClellan Ave., Detroit, Mich., Champion Porcelain Co.

*__Binns, C. F.__, Alfred, N. Y., Director, New York State School of Clay-Working and Ceramics.

*__Binns, Norah W.__, 225 King Ave., Columbus, Ohio, Asst. Sec., American Ceramic Society.

Birner, William, Box 139, R. R. 1, East San Gabriel, Cal., Washington Iron Works.

Bissell, G. F., Ottawa, Ill., Supt., Chicago Retort and Fire Brick Co.

Bitting, A. W., 3344 Michigan Ave., Chicago, Ill., Director of Research, Glass Container Association of America.

Bittner, A. G., Central Sta., St. Louis, Mo., National Enameling & Stamping Co.

Blackburn, C. A., Cleveland, Ohio, Gen. Supt., "Ivanhoe Plant," Cleveland Metal Products Co.

*__Blackmer, Edward L.__, 2801 Hereford St., St. Louis, Mo., Blackmer and Post Pipe Co.

Blair, J. A., Kushequa, Pa., Supt., Kushequa Brick Co.

*__Blair Marion W.__, 1934 Walnut St., Murphysboro, Ill.

*__Blair, William P.__, 824 B. of L. E. Bldg., Cleveland, Ohio, Vice-Pres., National Paving Brick Manufacturers' Association.

Blake, Alfred E., 1150 Greenfield Ave., Squirrel Hill District, Pittsburgh, Pa.

Blatchley, C. P., Manor Park House, Worksop, Notts., England, Mgr., The Steetley Lime Co. Ltd.

*Bleininger, A. V., Newell, W. Va., Homer-Laughlin China Co.

*Blewett, J. B., Wellsville, Ohio, McLain Fire Brick Co.

Blodgett, Malcolm, Woburn, Mass., Supt., R. Guastavino Co.

*Bloomfield, Chas. A., P. O. Drawer F, Metuchen, N. J., Treas., Bloomfield Clay Co.

Bloxsom, John J., Brookville, Pa., Supt., Brookville Glass and Tile Co.

Blum, John W., New Straitsville, Ohio, The Straitsville Impervious Brick Co.

Blumenthal, George Jr., 143 Industrial Bldg., Washington, D. C., U. S. Bureau of Standards.

Boblett, Edgar E., Box 131, Nappanee, Ind., Supt., Vitreous Steel Products Co.

*Boeck, P. A., 1736 Morgan Place, Hollywood, Los Angeles, Cal., Celite Products Co.

Bohlinger, George H. Jr., 51 McKinley Ave., Trenton, N. J., Student, Rutgers College.

*Bole, G. A., Columbus, Ohio, U. S. Bureau of Mines.

Bonner, James M. Jr., Robinson, Ill., Asst. Mgr., Zwermann Co.

*Booraem, J. Francis, 52 Vanderbilt Ave., New York City, Treas. and Mgr., American Enameled Brick and Tile Co.

*Booze, M. C., Woodland St., Holden, Mass., Norton Co.

Borg, H. E., 1601 6th St., Perry, Iowa.

Borkey, J. H., Land Title Bldg., Philadelphia, Pa., District Sales Agent, Elk Fire Brick Co.

Boudouard, O., 292 Rue Saint Martin, Paris, France, Professeur de Chemie.

Boudreau, James C., 725 Fulton Bldg., Pittsburgh, Pa., Director of Art Education.

*Boughey, Joseph, 513 Monmouth St., Trenton, N. J., Mgr., Porcelain Department, Charles Engelhard, Inc., Newark, N. J.

Bour, Lawrence J., Box 285, Scranton, Pa., President, L. J. Bour Refractories Co.

Bowles, George O., New Cumberland, W. Va.

*Bowman, Oliver O., 2nd, Trenton, N. J., Trenton Fire Clay and Porcelain Co.

*Bowman, William J. J., Trenton, N. J., Trenton Fire Clay and Porcelain Co.

Bowne, Edward, Cloverport, Ky., Murray Roofing Tile Co.

Bracken, Lloyd, 770 Coleman Ave., Clarksburg, W. Va., Furnace Foreman, Hazel-Atlas Glass Co.

Bragdon, William V., 2336 San Pablo Ave., Berkeley, Cal., "The Tile Shop."

Brain, George, Newcastle, Pa., Manager, Universal Sanitary Mfg. Co.

Bramlett, Mrs. J. T. (Address unknown).

Brand, J. J. Fred, Box 472, Roseville, Ohio.

Brann, Albert, 220 Springdale Ave., East Orange, N. J., Research Chemist, Westinghouse Lamp Co., Bloomfield, N. J.

†**Branner, John C.,** Stanford University, Cal., President, Leland Stanford Junior University.

Bray, A. C., Helena, Mont., Sec.-Treas., Associated Industries of Montana.

Breckenridge, James M., Vanderbilt University, Nashville, Tenn., Director, School of Chemistry.

Brenholtz, W. K., Flint, Mich., Foreman, Clay Preparation Dept., Champion Ignition Co.

Brennan, George L., 365 High St., Perth Amboy, N. J., Public Drafting.

Brenner, R. F., Rochester, Pa., H. C. Fry Glass Co.

Breskow, Samuel, 209 Fourth Ave., Pittsburgh, Pa., The O'Hommel Co.

Brett, R. C., (Address unknown).

*Brewster, Robert, Brentmere Hotel, N. Halstead Sta., Chicago, Ill.

*Breyer, Frank G., Palmerton, Pa., Chief of Research Department, New Jersey Zinc Co.

Brian, Chas., Easton, Pa., Gen. Mgr., Clay Department, Paper Makers Importing Co.

Brian, George, East Liverpool, Ohio, Salesman, Paper Makers Importing Co.

Bridge, Laurence D., 464 N. Taylor Ave., Kirkwood, Mo., Bridge & Beach Mfg. Co., St. Louis, Mo.

Briggs, Leonard S., 46 Yard Ave., Trenton, N. J., Lenox, Inc.

Brinckerhoff, James E., P. O. Box 108, East Liverpool, Ohio, Engineer, The Babcock & Wilcox Co.

Brinkman, S. G., Fords, N. J., Clay Mines and Fire Brick Works.

*Brockman, Edward A., 589 E. Illinois St., Chicago, Ill., Roessler & Hasslacher Chemical Co.

Broga, Wilson C., 67 Hillcroft Ave., Worcester, Mass., Norton Co.

Brogdon, J. S., 70½ Peachtree St., Atlanta, Ga., Consulting and Mfg. Chemist.

Brooks, B. T., 25 West 43rd St., New York City, Chemical Engineer, Mathieson Alkali Works, Inc.

Brown, Alexander M., Box 537, Sharon, Pa., Asst. Gen. Mgr. of Sales, Sharon Steel Hoop Co.

Brown, Byron P., Belvidere, Ill., Vice.-Pres. and Gen. Mgr., The Hercules Porcelain Co.

*Brown, Davis, Bucyrus, Ohio, Hadfield-Penfield Steel Co.

Brown, Edmund, 510 West Front St., Perrysburg, Ohio.

*__Brown, George H.,__ New Brunswick, N. J., Director, Department of Ceramics, Rutgers College.

Brown, Harry G., Box 196, Buffalo, Kan., Supt., Buffalo Brick Co.

Brown, Horace T., 402 Prospect Ave., Alton, Ill., Illinois Glass Co.

Brown, Lawrence H., East Liverpool, Ohio, The R. Thomas and Sons Co.

Brown, Leslie, Trenton, N. J., Lenox, Inc.

Brown, Richard P., Wayne Junction, Philadelphia, Pa., Pres., Brown Instrument Co.

Brown, Thomas G., St. Laurent, Quebec, Canada, Works Mgr., Gurney Foundry Co.

*__Brown, Wilbur F.,__ Charleston, W. Va., Chief Chemist, Libbey-Owens Sheet Glass Co.

*__Brownlee, Wm. K.,__ Toledo, Ohio, Pres. and Gen. Mgr., Buckeye Clay Pot Co.

Brownlee, Wm. L., Toledo, Ohio, Foreman, Clay Department, Buckeye Clay Pot Co.

Bruner, Willard L., 196 Water St., Perth Amboy, N. J., Chief Chemist, Roessler & Hasslacher Chemical Co.

*__Brush, Geroge S.,__ 1112 Lexington Ave., Zanesville, Ohio, Gen. Mgr., Brush-McCoy Pottery Co.

*__Bryan, M. L.,__ Spokane, Wash., Washington Brick, Lime and Sewer Pipe Co.

Buck, D. M., Pittsburgh, Pa., American Sheet and Tin Plate Co.

Buck, W. E., Granite City, Ill., Metallurgist, National Enameling and Stamping Co.

Buck, Wiley E., Chestnut St. Ext., East Liverpool, Ohio.

Buckley, Jos. L., Robinson Bldg., Rock Island, Ill.

*__Buckner, O. S.,__ 44 Wellington St., Worcester, Mass., Norton Co.

Buettner, Pete, Box 239, Eastern Ave., Baltimore, Md., Porcelain Enamel and Mfg. Co.

Bunting, Elmer N., 203 Ceramics Bldg., Urbana, Ill., Research Associate, Dept. of Ceramic Engineering, University of Illinois.

Burchfiel, B. M., Alberhill, Cal., Los Angeles Pressed Brick Co.

Burdick, Percy W., 603 24th St., Niagara Falls, N. Y., Ceramic Chemist, Carborundum Co.

Burgess, M. L., Indianapolis, Ind., Sec.-Treas., Marietta Mfg. Co.

*__Burroughs, Francis H.,__ Trenton, N. J., Star Porcelain Co.

Burt, F. M., Massillon, Ohio, American Stamping and Enameling Co.

Burt, N. P., Leavenworth, Kan., Great Western Stove Co.

*__Burt, S. G.,__ 2349 Ashland Ave., Cincinnati, Ohio, Rookwood Pottery.

Burton, R. C., Zanesville, Ohio, Pres., Burton-Townsend Co.

Busch, Albert D., 5379 Pershing Ave., St. Louis, Mo., The W. S. Tyler Co.

Bush, H. T., 1408 Royal Bank Bldg., Toronto, Ontario, Canada.

Bussell, William T., The Clay Products Co., Brazil, Ind., Pant Supt.

Butterfield, Fred H., 4906 McPherson Ave., St. Louis, Mo., Plant Mgr., Crunden Martin Mfg. Co.

***Butterworth, Frank W.**, Danville, Ill., Gen. Mgr., Western Brick Co.

Cable, Davis A., 316 Dryden Ct. N. W., Canton, Ohio.

Cable, Margaret K., Grand Forks, N. Dak., Instructor in Ceramics, University of North Dakota.

Cake, B. F., Renton, Wash., Supt., Denny-Renton Clay and Coal Co.

Callaghan, J. P., (Address unknown).

Callahan, H. D., 434 East Long St., Columbus, Ohio.

Cameron, A. C., North East, Md., Mgr., North East Fire Brick Co.

Cameron, C. V., Box V, Richmond, Cal., Supt., Pacific Sanitary Mfg. Co.

***Campbell, A. R.**, Middlesex Ave., Metuchen, N. J., Federal Terra Cotta Co.

***Cannan, William Jr.**, 522 Allen St., Syracuse, N. Y., Onondaga Pottery.

***Carder, Frederic R.**, Corning, N. Y., Steuben Glass Works.

Carhart, C. C., Sheffield, Iowa.

Carhart, F. F., Sheffield, Iowa, Pres., Sheffield Brick and Tile Co.

Carman, C. F., Berkeley Springs, W. Va., Pres., National Silica Works.

Carothers, Richard B., 5th and Monmouth Sts., Newport, Ky., Asst. Mgr., H. C. Spinks Clay Co.

Carruthers, John Lister, 2536 West 34th Ave., Denver, Colo., Ceramic Engineers, Denver Terra Cotta Co.

Carson, Edna P., Schenley High School, Pittsburgh, Pa., Teacher of Modeling and Pottery.

Carspecken, H. L., Morgantown, W. Va., Mgr., Mississippi Glass Co.

Carter, B. F., 565 Linn St., Peoria, Ill., Peoria Brick and Tile Co.

Case, W. W. Jr., Denver Athletic Club, Denver, Colo., Treas., Lalley Western Electric Co.

Casey, Charles L., Cambridge, Ohio, Pres., Guernseyware Co.

Casey, J. B., Colfax, Ind., Vice-Pres. and Gen. Mgr., Colfax Drain Tile Co.

Cassady, Bertram L., Box 1, Chippewa Lake, Ohio.

Castro, Oliveira, Rodolfo, Box 188, Alfred, N. Y., Student, New York State School of Clay-Working and Ceramics.

Cawood, Richard L., East Liverpool, Ohio, Vice-Pres. and Gen. Mgr., Patterson Foundry and Machine Co.

***Cermak, Frank**, 116 4th Ave., Schenectady, N. Y., Foreman, Porcelain Works, General Electric Co.

Cerney, Louis, 438 Roseberry Ave., Huntington Park, Cal.

Chamberlain, C. H., 16 Gladstone St., Rochester, N. Y., Head of Glass Research Dept., Taylor Instrument Companies.

Chambers, A. R., 805 Greenwood Ave., Trenton, N. J.

Chandler, A. H., 1618 Frick Bldg., Pittsburgh, Pa., Mgr., Refractories Dept., Pittsburgh Plate Glass Co.

Chapman, Dorothy Peck, 353 Federal St., Greenfield, Mass.

Charron R. C., 24 School St., Leominster, Mass.

Chatham, C. W., 1407 Arrott Bldg., Pittsburgh, Pa., Mgr., Eagle-Picher Lead Co.

Chesler, Isidor, 710 East 14th St., New York City, Industrial Engineer, Eagle Pencil Co.

*__Child, J. L.,__ Findlay, Ohio, Hancock Brick and Tile Co.

*__Chormann, O. I.,__ 487 Arnett Blvd., Rochester, N. Y., Pfaudler Co.

*__Christman, C. E.,__ Pittsburgh, Pa., Pres., Federal Stamping and Enameling Co.

Christopher, Arthur B., St. Louis, Mo., Ceramic Engineer, Evens & Howard Fire Brick Co.

Chu, Kea Hin, FC 562 Medhurst Rd., Shanghai, China.

Clare, H. L., Hespeler, Ontario, Canada, Sales Mgr., Stamped and Enameled Ware.

*__Clare, Robert L.,__ Woodbridge, N. J., Supt., Federal Terra Cotta Co.

Clark, Ernest, Terra Cotta, Ill., Sup., American Terra Cotta and Ceramic Co.

Clark, Horace H., 325 Peoples Gas Bldg., Chicago, Ill., Fuel Engineer.

Clark, John, 292 Lockwood St., Astoria, N. Y., Supt., New York Architectural Terra Cotta Co.

*__Clark, William M.,__ 1133 East 152nd St., Cleveland, Ohio, National Lamp Works of the General Electric Co.

Clayter, Frederic C., University of Pittsburgh, Pittsburgh, Pa., Art Department.

Clemens, Edward F., Cannelton, Ind., Sec., Cannelton Sewer Pipe Co.

Cleverly, Wm. B. Jr., 652 Leek Rd., Stoke-on-Trent, England, c/o Messrs. John Slater, Ltd., Berry Hill Brick Works.

Coad Pryor, E. A., Director of Laboratories, Anchor and Hope Lane, Charlton, S. E. 7, London, England, British Glass Industries, Ltd.

Coates, William W. Jr., 505 Tennessee St., Lawrence, Kan., Lawrence Tile Co.

Cobb, John W., Leeds, England, Fuel Department, The University.

Colburn, Ed. D., 2801 Hereford St., St. Louis, Mo., Supt., Blackmer & Post Pipe Co.

Cole, G. Percy, Montreal, Canada, Technical Engineer, Dominion Glass Co., Ltd.

Cole, L. Heber, Mines Branch, Department of Mines, Ottawa, Ontario, Canada.

Cole, M. J., Logan, Ohio, Supt. and Treas., The Logan Clay Products Co.

Cole, Sanford S., Alfred, N. Y., Student, New York State School of Clay-Working and Ceramics.

Collin, Louis, Delta Sigma Phi House, Alfred, N. Y.

Conard, John B., 91 W. Third St., Mansfield, Ohio, Supt., Richland Shale and Brick Co.

*__Conkling, Samuel O.,__ Philadelphia, Pa., Supt., Conkling-Armstrong Terra Cotta Co.

*__Cook, Chas. H.,__ Trenton, N. J., Cook Pottery Co.

Cooke, May E., 1550 Clifton Ave., Columbus, Ohio.

*__Cooke, Raymond D.,__ Terre Haute, Ind., Chemist, Columbian Enameling and Stamping Co.

Cooper, George W., Room 608, 19 Liberty St., New York City, Publisher, "The Glass Industry."

*__Coors, H. F.,__ 1817 Arapahoe St., Golden, Colo.

Corl, Robert M., 328 Bank of Commerce Bldg., Toledo, Ohio, Designer of Glass Machinery.

Corrigan, F. S., Toronto, Ont., Canada, Sheet Metal Products Co.

Corty, Charles J. Jr., 1015 Arthur St., Belleville, Ill., Supt., American Range and Foundry Co.

Cossette, Louis J., 1821 Vernon St., N. W. Washington, D. C., U. S. Bureau of Standards.

Coté, A. U., Cooksville, Ont., Canada, Gen. Mgr., Shale Brick Co. of Canada.

*__Coulston, E. V.,__ Rock Island, Ill., Sec., Rock Island Stove Co.

Coulter, Allen S., Reisholz bei Düsseldorf, Germany, Deutsche-Carborundum Werke.

Couture, Donald, 432 Summer Ave., Newark, N. J., Edison Lamp Works of the General Electric Co.

*__Covan, H. E.,__ 12369 Euclid Ave., Cleveland, Ohio, The Price Electric Co.

*__Cowan, R. G.,__ Cleveland, Ohio, Treas., Cleveland Pottery and Tile Co., "Cowan Pottery."

Cox, Harold N., 48 Woodland Ave., Glen Ridge, N. J.

*__Cox, Paul E.,__ Ames, Iowa, Professor, Ceramic Engineering, Iowa State College.

Cox, S. Frank, Creighton, Pa., Pittsburgh Plate Glass Co.

Coxon, J. B., Kokomo, Ind., Asst. Supt., Standard Sanitary Mfg. Co.

Coxon, J. Frederick, Fredericksburg, Ohio, Pres., Wooster Sanitary Mfg. Co.

Craig, Robert H., 15607 Loomis Ave., Harvey, Ill., Geo. M. Clark & Co.

Cramer, W. E., 66 S. Third St., Columbus, Ohio.

*Crane, Charles W., 17 Battery Place, New York City, Pres. and Treas., The Barrett Co.

Crawford, Charles J., 5510 Pershing Ave., St. Louis, Mo., Gen. Mgr., Crawford Refractories Co.

Crawford, George E., 914 Hamilton Ave., Trenton, N. J.

*Crawford, J. L., Mellon Institute, Pittsburgh, Pa.

*Creighton, E. E. F., 27 Wendell Ave., Schenectady, N. Y., General Electric Co.

Crew, H. F., 359 Lenox Ave., Zanesville, Ohio, American Encaustic Tiling Co.

Crimmel, H. H., Hartford City, Ind., Sneath Glass Co.

Cronin, W. Kress, 177 Pennsylvania Ave., East Liverpool, Ohio, Standard Pottery Co.

*Cronquist, Gustaf Wson, Rikstel 153, Helsingborg, Sweden.

Cronshaw, H. B. Brierley Hill, South Staffordshire, England, Principal, Technical Institute.

Crow, Waller, 2828 Smallman St., Pittsburgh, Pa., Sec.-Treas., Schaffer Engineering and Equipment Co.

Crownover, A. W., Mount Winans, Md., Factory Mgr., Maryland Glass Corp.

*Cruikshank, J. W., 230 Fifth Ave., Pittsburgh, Pa., Consulting Engineer.

Crume, Wm. H., 800 U. B. Bldg., Dayton, Ohio, Pres. and Gen. Mgr., Crume Brick Co.

Cunning, George B., New Lexington, Ohio, Gen. Mgr., Liberty China Co.

Cunning, W. E., East Liverpool, Ohio, Pres., West End Pottery Co.

Cunningham, Matthias F., Waltham, Mass., Superior Corundum Wheel Co.

Curran, Hugh, 1898 N. High St., Columbus. Ohio.

Curtis, Algernon Lewin, Westmoor Laboratory, Chatteris, Cambridgeshire, England, Consulting Expert in Lands, Clays and Refractories.

Curtis, Thomas S., 109 N. Rugby Ave., Huntington Park, Los Angeles, Cal.

Cushman, H. D., 819 Finance Bldg., Cleveland, Ohio, Pres., Ferro Enameling Co.

Cuthbertson, M. R., Oroya, Peru, South America, Supt. Brick Plants, Cerro de Pasco Copper Corp.

Dailey, Ernest W., Mason City, Iowa, Sec. and Treas., North Iowa Brick and Tile Co.

*Dains, I. F., Monmouth, Ill., Pres. and Gen. Mgr., Western Stoneware Co.

Dalton, Richard F., 401 Vernon Ave., Long Island City, N. Y., Pres., New York Architectural Terra Cotta Co.

Dana, Leslie, St. Louis, Mo., Pres., Charter Oak Stove and Range Co.

Dandurand, Raymond A., The Clay Products Co., Brazil, Ind., Sec.

Danes, August F., 5937 Arsenal St., St. Louis, Mo., Laclede-Christy Clay Products Co.

*__Danielson, R. R.__, 143 Industrial Bldg., Washington, D. C., U. S. Bureau of Standards.

Darlington, Homer T., Box 736, Natrona, Pa., Metallurgical Engineer, Pennsylvania Salt Mfg. Co.

*__Davenport, R. W.__, 1583 Hurlbut Ave., Detroit, Mich.

Davidson, T. R., Thos. Davidson Mfg. Co., P. O. Box 700, Montreal, Canada.

Davies, J. L., (Address unknown).

Davis, Harry E., Chicago, Ill., Northwestern Terra Cotta Co.

*__Davis, John B.__, 22 East Greenwood Ave., Lansdowne, Pa.

*__Davis, N. B.__, 410 Union Bank Bldg., Ottawa, Canada, M. J. O'Brien, Ltd.

Davis, S. E., 1117 Murdock Ave., Parkersburg, W. Va., General Porcelain Co.

*__Day, Arthur L.__, Washington, D. C., Director, Geophysical Laboratory,

Day, O. L., 1513 Kirby Bldg., Cleveland, Ohio, Harbison-Walker Refractories Co.

Dean, Charles A., 79 12th Ave., Columbus, Ohio.

Deaver, L. A., 29 Dodge Ave., Akron, Ohio.

Deb, S., 45 Tangra Road, Calcutta, India, Mgr., Calcutta Pottery Works.

Dell, John M., St. Louis, Mo., Missouri Fire Brick Co.

*__DeLuze, Henri__, Avenue de Poitiers, Limoges, France, Haviland Porcelaine Co.

Denis, T. C., Parliament Bldg., Quebec, Canada, Supt. of Mines of Province of Quebec.

*__Denk, F. J.__, 1216 House Bldg., Pittsburgh, Pa., Consulting Engineer.

Dennis, J. Alfred, Trenton, N. J., Supt., Golding Sons Co.

Deppeler, J. H., Jersey City, N. J., Chief Engineer, Thermit Dept., Metal and Thermit Corp.

*__DeVoe, Chas. H.__, Old Bridge, N. J., Old Bridge Enameled Brick and Tile Co.

*__DeWitt, Bert G.__, New Philadelphia, Ohio, Supt., Belmont Stamping and Enameling Co.

*__Dickey, Fred L.__, Kansas City, Mo., Gen. Mgr., W. S. Dickey Clay Mfg. Co.

Dingledine, H. F., Aldershot, Ont., Canada, Factory Mgr., National Fire Proofing Co. of Canada, Ltd.

*Dinsmore, B. B., Trenton, N. J., Gen. Mgr., Imperial Porcelain Works.

Dinwiddie, Redfield, Box 108, East Liverpool, Ohio, Ceramist, The Babcock & Wilcox Co.

Dittmar, Carl, 1740 East 12th St., Cleveland, Ohio, Mgr., Roessler & Hasslacher Chemical Co.

*Dixon, Henry L., Box 140, Pittsburgh, Pa., Pres. and Gen. Mgr., H. L. Dixon Co.

Doane, G. Earl, Poplar Bluff, Mo.

*Dobbins, T. Monroe, Camden, N. J., Sec.-Treas., Camden Pottery Co.

Dolley, Charles S., (Address unknown).

Dolman, C. D., Box 274, Chewelah, Wash., Chief Chemist, Northwest Magnesite Co.

Donahoe, Frederic W., 840 Oliver Bldg., Pittsburgh, Pa., Sec., The Refractories Manufacturers' Association.

*Dornbach, Wm. E., 3514 Clifton Ave., Baltimore, Md., American Refractories Co.

*Douda, Henry W., 1927 Waldeck Ave., Columbus, Ohio, U. S. Bureau of Mines.

Dougherty, Robert H., Nela Park, Cleveland, Ohio, Asst. to Ceramic Engineer in Engineering Laboratory, National Lamp Works.

Drakenfield, B. F. Jr., 50 Murray St, New York City, Treas., B. F. Drakenfeld & Co., Inc.

*Dressler, Conrad, 1740 East 12th St., Cleveland, Ohio, American Dressler Tunnel Kilns, Inc.

Dressler, Philip, 1551 East Boulevard, Cleveland, Ohio, American Dressler Tunnel Kilns, Inc.

Dufour, G. F., Aniche, (Nord), France.

Duhart, A. L., Port Allegany, Pa., Asst. Mgr., Mississippi Glass Co.

Dunbar, George S., Columbus, Ohio, Sec., Federal Glass Co.

Duncombe, George M. Jr., 1450 Tamm Ave., St. Louis, Mo.

*Dunn, Frank B., Conneaut, Ohio, Pres. and Treas., Dunn Wire Cut Lug Brick Co.

Durant, E. M., 603 American Bank Bldg., Los Angeles, Cal., Pres., Pacific Sewer Pipe Co.

Duty, S. M., 4900 Euclid Ave., Cleveland, Ohio, Pres. and Treas., The Medal Paving Brick Co.

Duval, A. M., 901 North Forest Ave., Brazil, Ind., Salesman, The Manufacturers Equipment Co.

*Duval D'Adrian, A. L., 284 South Main St., Washington, Pa.

Earl, Oliver N., Box 97, East Liverpool, Ohio, Harshaw, Fuller & Goodwin Co.

Early, Joseph W., Dickson City, Pa., Supt., Early Foundry Co.

Eaton, Arthur E., Mineral Wells Paving Brick Co., Mineral Wells, Texas.

*Ebinger, D. H. Jr., 735 Linwood Ave., Columbus, Ohio, Sec. and Gen. Mgr., D. A. Ebinger Sanitary Mfg. Co.

Eckert, Joseph R., 18 W. Jackson St., Webster Groves, Mo., Winkle Terra Cotta Co.

*Edgar, David R., Metuchen, N. J., Asst. Gen. Mgr., Edgar Bros. Co.

Edson, S. P., Bryantville, Mass., Supt. and Enameler, Wheeler Reflector Co.

Edwards, W. L., Tiltonville, Ohio, Asst. Supt., Wheeling Sanitary

Eells, Howard P. Jr., 1110 Euclid Ave., Cleveland, Ohio, Pres. and Gen. Mgr., The Dolomite Products Co.
Mfg. Co.

Eilers, H. F., 162 Watauga Ave., Corning, N. Y., Mechanical Engineer, Corning Glass Works.

Elledge, H. G., 3384 Webster Ave., Pittsburgh, Pa., Technical Asst. to Gen. Sales Mgr., Diamond Alkali Co.

*Ellerbeck, William L., Box 917, Salt Lake City, Utah, Pres. and Mgr., Nephi Plaster Co.

Ells, Leon Elmer, Alfred, N. Y., Student, New York State School of

Elsenius, Charles A. 1631 Woolsey St., Berkeley, Cal.
Clay-Working and Ceramics.

*Emley, Warren E., Washington, D. C., U. S. Bureau of Standards.

Emminger, Thomas F., 1247-1261 Reedsdale St., North Side, Pittsburgh, Pa., Pittsburgh Clay Pot Co.

Endell, Kurd, Berlin Steglitz, Breitestr. 3, Germany.

Engle, C. C., Trenton, N. J., United Clay Mines Corp.

†English Ceramic Society, Stoke-on-Trent, Staffordshire, England.

Erdmann, K., Radenthein, Kaernten, Austria, Gen. Director, Austro-American Magnesite Co.

*Eskesen, B. K., Matawan, N. J., Pres. and Gen. Supt., Matawan Tile Co.

*Eskesen, E. V., 149 Broadway, New York City, Pres., N. J. Terra Cotta Co.

Evans, A. W., Zanesville, Ohio.

Evatt, Franks G., 350 Madison Ave., New York City, Vice-Pres., Atlantic Terra Cotta Co.

Ewart, Henry, 922 Broad St., Columbus, Ga., The Minter System.

Ewing, R. F., 1602 Clark Ave., Wellsville, Ohio, McLain Fire Brick Co.

*Fackt, George P., Denver, Colo., Gen. Mgr., Denver Terra Cotta Co.

*Farnham, D. T., 52 Vanderbilt Ave., New York City, Vice-Pres., C. E. Knoeppel & Co., Inc.

Farren, Mabel C., 403 A Iroquois Apartments, 3600 Forbes St., Pittsburgh, Pa., Private Studio.

Farris, P. C., 9 W. Park St., Brazil, Ind., Supt., Hydraulic Pressed Brick Co.

Faulkner, Karl B., Corning, N. Y., Foreman, Pot Department, Corning Glass Works.

Fenton, Harry W., 1419 Lowell Ave., Lima, Ohio.

Ferguson, Richard D., 2036 South 26th St., Lincoln, Neb.

Ferguson, Robert F., Mellon Institute, Pittsburgh, Pa.

*__Fettke, Charles R.__, Pittsburgh, Pa., Carnegie Institute of Technology.

*__Fickes, W. M.__, Badin, Stanley Co., N. C., Tallassee Power Co.

Finn, Alfred Nelson, Washington, D. C., U. S. Bureau of Standards, Optical Glass Section.

Finney, Robert S., 142 West 80th St., New York City, Parsons Trading Co.

*__Fisher, Douglas J.__, Sayreville, N. J., Sayre & Fisher Co.

Fisher, E. E., 2749 Monroe St., Toledo, Ohio.

*__Fisher, George P.__, Ottawa, Ill., Supt., National Fireproofing Co.

*__Fiske, J. Parker B.__, Arena Bldg., New York City.

Fitz-Gerald, Gerald, Muncie, Ind., Engineer, Maxon Furnace and Engineering Co.

Fitzpatrick, John, 39 Roebling Place, Niagara Falls, N. Y., Carborundum Co.

Flagg, Frederick P., 20 Floyd St., Waltham, Mass., Chief Chemist, Waltham Watch Co.

Flint, Francis C., 303 South Main St., Washington, Pa., Chief Chemist, Hazel-Atlas Glass Co.

Foersterling, Hans, The Abor Farm, Jamesburg, N. J.

Fogelberg, Sven, Kosta, Sweden, Direktor's Asst., Kosta Glass Works.

Foley, Fenwick D., Loch Lomond Road, St. John, N. B.

*__Foltz, Andrew__, 187 N. Union St., Lambertville, N. J., Pres., Lambertville Pottery Co.

Ford, George D., 104 Woodlawn Ave., Zanesville, Ohio, Ceramic Engineer, Mosaic Tile Co.

Ford, Karl L., 3555 11th St., N. W., Washington, D. C., U. S. Bureau of Standards.

Forester, Herbert, Box 37, Cleveland, Ohio, Prin., Veritas Firing System Co.

Forman, L. P., Arnold, Pa., American Window Glass Co.

*__Forst, Arthur D.__, Trenton, N. J., Pres., Robertson Art Tile Co.

*__Forst, Daniel P.__, 455 West State St., Trenton, N. J., Factory Mgr., Robertson Art Tile Co.

Forsyth, J. H., Cleveland, Ohio, Associate Chemist, Glass Technology Dept., National Lamp Works of General Electric Co.

Foskett, John J., 11 Neversink Ave., Port Jervis, N. Y., Pres. and Mgr., Foskett & Co., Inc.

Foster, Harry D., 266 Industrial Bldg., Washington, D. C., U. S. Bureau of Standards.

Francais, Paul P., Box 46, Frankfort, Ind., Supt., Ingram-Richardson Mfg. Co.

Francis, W. H., Cherryvale, Kansas, Supt., Coffeyville Vitrified Brick and Tile Co.

Frank, G. Harry, 3328 Monroe St., Chicago, Ill., The Meyercord Co.

Frantz, Samuel G., Crossett, Ark., Engineer in charge, By-Products Development, Crossett Lumber Co.

Franzen, Nick, Port Allegany, Pa., Mgr., Mississippi Glass Co.

Franzheim, C. Merts, Wheeling, W. Va., The Chas. M. Franzheim Co.

*__Fraser, W. B.__, Dallas, Texas, Fraser Brick Co.

*__Fraunfelter, Chas. D.__, Zanesville, Ohio, Pres., Ohio Pottery Co.

Frazier, C. E., Washington, Pa., Pres., Simplex Engineering Co.

*__Fredriksson, Nils__, Royal Board of Schools, Stockholm, Sweden.

Freeman, Jonathan W., 801 Century Bldg., Pittsburgh, Pa., Sales Engineer, Mathews Gravity Carrier Co., Ellwood City, Pa.

*__Freese, H. H.__, 446 S. Union St., Galion, Ohio, Mechanical Engineer, E. M. Freese Co.

Frey, Wm. J., 304 W. Adams St., Sandusky, Ohio, Supt., Universal Clay Products Co.

Friderichsen, Christian, 106 South Liberty St., Independence, Mo., Gen. Mgr., Friderichsen Floor and Wall Tile Co.

*__Frink, R. L.__, 50 Bedford Square, London, W. C. 1, Director of Research, Glass Research Association.

*__Fritz, E. H.__, Box 510, Derry, Pa., Westinghouse Electric and Mfg. Co.

*__Frost, Leon J.__, Box 67, Station D, Cleveland, Ohio, The Vitreous Enameling Co.

Frost, Samuel, Box 646, East Liverpool, Ohio.

Fujioka, Koji, Kyoto, Japan, Shofu Porcelain Mfg. Co.

*__Fuller, Donald H.__, Washington, D. C., Ceramic Assistant, U. S. Bureau of Standards.

Fuller, George W., Spokane, Wash., Librarian, Spokane Public Library.

Fuller, J. R., 22 Highland Ave., Salem, Mass., Engineering Department, Hygrade Lamp Co.

*__Fulper, Wm. H.__, Flemington, N. J., Sec.-Treas., Fulper Pottery.

*__Fulton, C. E.__, Creighton, Pa., Pittsburgh Plate Glass Co.

*__Fulweiler, Walter H.__, 319 Arch St., Philadelphia, Pa., United Gas Improvement Co.

Funkhouser, E. N., Hagerstown, Md., Sec., Maryland Glass Sand Co.

Gaby, F. A., 190 University Ave., Toronto, Ont., Canada, Chief Engineer, Hydro-Electric Power Co.

*__Gahris, Willard I.__, Sebring, Ohio, Limoges China Co.

Galloway, Walter B., 32nd and Walnut Sts., Philadelphia, Pa., Pres., Galloway Terra Cotta Co.

*Galpin, Sidney L., Iowa State College, Ames, Iowa, Dept. of Mining and Geology.

Gardner, William, Hartington, Ont., Canada, Gardner Feldspar Co.

Gardner, W. J., Meltham, near Huddersfield, England, Managing Director, The Meltham Silica Fire Brick Co., Ltd.

Garrison, A. A., 149 Goltz St., Salt Lake City, Utah.

Garrod, Fred B., Toledo, Ohio, Chemist, Owens Bottle Co.

*Garve, T. W., Box 253, New Hope, Pa.

Gass, George Pool, "The Hollins," The Haulgh, Bolton, England, Director, Entwish & Gass, Ltd.

Gassman, H. M., 848 Brown Marx Bldg., Birmingham, Ala., Consulting Engineer.

Gatecliff, John, Rugby, England, Chemist, The Lodge Sparking Plug Co., Ltd.

*Gates, A. W., Colchester, Ill., Gates Fire Clay Co.

*Gates, Ellis D., Box 31, Santa Fé, N. Mex.

*Gates, Major E., Terra Cotta, Ill., Asst. Gen. Mgr., American Terra Cotta and Ceramic Co.

*Gates, Wm. D., 1808 Prairie Ave., Chicago, Ill., Pres. and Gen. Mgr., American Terra Cotta and Ceramic Co.

Gayner, J. William, Salem, N. J., Gayner Glass Works.

Geer, Walter Jr., 401 Vernon Ave., Long Island City, N. Y., Vice-Pres., New York Architectural Terra Cotta Co.

Gehrig, Edward F., Detroit, Mich., Research Engineer, Detroit Stove Works.

Geiger, Carl F., 427 Valley St., Dayton, Ohio, Valley Engineering Co.

*Geiger, Charles F., Perth Amboy, N. J., The Carborundum Co.

*Geijsbeek, Samuel, 635 Burke Bldg., Seattle, Wash., Geijsbeek Engineering Co.

*Geisinger, E. E., Rochester, N. Y., The Pfaudler Co.

*Geller, Roman F., Industrial Building, Washington, D. C., U. S. Bureau of Standards.

*Gelstharp, Frederick, Creighton, Pa., Pittsburgh Plate Glass Co.

Gentil, E., Glaeeries de St. Gobain, 1 bis Place des Saussaies, Paris, France, Engineer.

George, J. S., 135 Rebecca St., Kittanning, Pa., U. S. Bureau of Standards.

George, W. C., 286 Alice St., East Palestine, Ohio, Vice-Pres., W. S. George Pottery Co.

Gernon, Ursula T., Brookings, S. D., Craft Instructor, South Dakota State College.

Gesner, M. A., Ridgewood, N. J., Hammill & Gillespie, Inc.

Geuder, George, 38 15th St., Milwaukee, Wis.

*Gibbs, A. E., 1006 Widener Bldg., Philadelphia, Pa.

Gibson, M. F., Toronto, Ont., Canada, Managing Director, National Fireproofing Co. of Canada.

Gieseke, Wilhelm, Ronneby, Sweden, Managing Director, Kockums Enameling Works.

Giesey, V. A., 634 Schofield Bldg., Cleveland, Ohio.

Gilfillan, J. M., The Trumbull Electric Mfg. Co., Trenton, N. J.

Gillespie, M. H., 240 Front St., New York City, Hammill & Gillespie, Inc.

*Gillinder, James, 11 Orange St., Port Jervis, N. Y., Supt., Gillinder Bros.

Gilmore, R. B., Columbus, Ohio, U. S. Bureau of Mines.

*Gladding, A. L., Lincoln, Cal., Gladding, McBean & Co.

Glass, L. G., 603 Queens Ave., London, Ont., Canada, Engineer, McClary Mfg. Co.

*Gleason, Marshall W., 864 Park Place, Brooklyn, N. Y., Pres. and Gen. Mgr., Gleason-Tiebout Glass Co.

Goddard, W. T., Box 170, Hamilton, Canada.

Godejohn, W. F., 4539a Clarence Ave., St. Louis, Mo., Industrial Engineer, Laclede-Christy Clay Products Co.

Goebel, Julius, Jr., South Highland Ave., Nyack, N. Y., J. Goebel & Co.

*Goheen, John P., Philadelphia, Pa., Sec., Brown Instrument Co.

Golding, Charles E., 217 S. Warren St., Trenton, N. J., Mgr., Trenton Dept., Golding Sons Co.

Goldsmith, B. B., 19 East 74th St., New York City, Vice-Pres., American Lead Pencil Co.

Gonder, Lawton G., Zanesville, Ohio, Research Dept., American Encaustic Tiling Co.

Goodman, A. H., Box 915, Pittsburgh, Pa., Sales Engineer, Blaw-Knox Co.

Goodner, Ernest F., Spokane, Wash., Washington Brick Lime and Sewer Pipe Co.

Goodwin, Herbert, East Liverpool, Ohio.

*Gorton, Arthur F., Cleveland, Ohio, Physicist, Research Laboratory, The National Malleable Castings Co.

Grace, Richard P., Woodbridge, N. J., Supt., Mutton Hollow Fire Brick Co.

*Grady, Robert F., St. Louis, Mo., Mgr., St. Louis Terra Cotta Co.

*Grafton, Chas. O., Muncie, Ind., Treas. and Gen. Mgr., Gill Clay Pot Co.

Grafton, C. V., Muncie, Ind., Treas. and Gen. Mgr., Muncie Clay Products Co.

*Grainer, John S., Grand Haven, Mich., Challenge Refrigerator Co.

*Grant, DeForest, 101 Park Ave., New York City, Pres., Federal Terra Cotta Co.

Grant, Frederic J., 134 Woodlawn Ave., Zanesville, Ohio, Mosaic Tile Co.

Grant, W. Henry, St. Marys, Pa., Elk Fire Brick Co.

Gray, Arthur E., 1247-1261 Reedsdale St., North Side, Pittsburgh, Pa., Pittsburgh Clay Pot Co.

Gray, John R., 4311 Scovel Place, Detroit, Mich., Champion Porcelain Co.

*Greaves-Walker, A. F., Box 1122, Pittsburgh, Pa., Production Mgr., American Refractories Co.

*Green, J. L., St. Louis, Mo., Pres., Laclede-Christy Clay Products Co.

Greene, R. J., 156 W. Indiana Ave., Sebring, Ohio, Foreman, Gem Clay Forming Co.

Greene, R. W., Mayfield, Ky., Kentucky Construction and Improvement Co.

Greenough, Maurice B., 830 Engineers Bldg., Cleveland, Ohio, Sec., National Paving Brick Manufacturers' Association.

Greenwood, G. W., Dunbar, Pa.

Greenwood, John L., (Address unknown).

Gregg, Henry, Knottingley, England, Gregg & Co.

Gregori, Andrew, 16th St. and 54th Ave., Cicero, Ill., Midland Terra Cotta Co.

Gregori, John N., Chicago, Ill., Northwestern Terra Cotta Co.

Gregorius, Thos. K., Corning, N. Y., Ceramic Engineer, Corning Glass Works.

Gregory, M. C., Corning, N. Y., Ceramic Engineer, Corning Brick Terra Cotta and Tile Co.

*Gregory, M. E., Corning, N. Y., Proprietor, Corning Brick Terra Cotta and Tile Co.

Griffin, Carl H., Wesseling bei Koeln, Germany, Deutsche Norton Gesselschaft.

Griffith, R. E., 670 Bullitt Bldg., Philadelphia, Pa., Mgr., Refractories Sales, E. J. Lavino & Co.

Groocock, Alice, Lombard Bldg., 70 Lombard St., Toronto, Ont., Canada.

*Grueby, Wm. H., Perth Amboy, N. J.

*Guastavino, Rafael Jr., Fuller Bldg., Broadway and 23rd St., New York City, Pres., R. Guastavino Co.

Guenther, Emil B., 351 S. Negley Ave., Pittsburgh, Pa., Harbison-Walker Refractories Co.

Gunn, James, 59 King Edward Ave., Toronto, Ont., Canada, Chemist.

Gunther, Franklin W., Ottawa, Ill., Supt., National Fire Proofing Co.

Guthrie, Chester, Hillsboro, Ill., Pottery Foreman, Eagle-Picher Lead Co.

Guthrie, Lee, Elyria, Ohio, Foreman, Elyria Enameled Products Co.

Gutman, Paul F., 4248 Blaine Ave., St. Louis, Mo., Asst. Supt., Mississippi Glass Co.

***Haaf, George,** 126 Franklin Ave., Solvay, N. Y.

Haberstroh, Herbert N., 53 W. Jackson Blvd., Chicago, Ill., Sales Engineer, Celite Products Co.

Haeger, E. H., Dundee, Ill., Pres., The Haeger Potteries, Inc.

Hagar, Donald, Matawan, N. J., Supt., Plant 2, Mosaic Tile Co.

Hahn, Carl A., 2138 Blendon Place, St. Louis, Mo., Asst. Engineer, Parker Russell Mining and Mfg. Co.

Hail, Walter, 2801 Hereford St., St. Louis, Mo., Blackmer & Post Pipe Co.

***Haley, Mark A.,** 854 Maryland Ave., Syracuse, N. Y., Onondaga Pottery Co.

***Hall, Clarence A.,** Allen Lane, Mt. Airy, Philadelphia, Pa.

Hall, F. P., 906 Crittenden St., Washington, D. C., Asst. Chemist, U. S. Bureau of Standards.

Hall, Herman A., (Address unknown).

Hall, William C., 1302 3rd National Bank Bldg., Atlanta, Ga., Vice-Pres., Atlanta Terra Cotta Co.

Hamilton, James, Trenton, N. J., Supt., Ideal Pottery of The Trenton Potteries.

Hammer, John M., Box 555, Pittsburgh, Pa., Managing Editor, "China Glass and Lamps."

Handke, Paul A., 260 S. Academy St., Galesburg, Ill., Asst. Supt., Purington Paving Brick Co.

Handy, James O., Box 1115, Pittsburgh, Pa., Director of Special Investigations, Pittsburgh Test Laboratory.

Hanley, William Lee, 2 Main St., Bradford, Pa., Gen. Mgr., Bradford Brick and Tile Co.

Hanna, Harold H., Crystal City, Mo., Pittsburgh Plate Glass Co.

***Hansen, Abel,** Fords, N. J., Fords Porcelain Works.

Hansen, J. E., Pittsburgh, Pa., Mellon Institute.

Hardesty, B. D., Beaver Falls, Pa., The Mayer China Co.

Harding, Browne, 586 Atwells Ave., Providence, R. I., Experimental Engineer, Providence Base Works of General Electric Co.

Harding, C. Knox, 6318 Stoney Island Blvd., Chicago, Ill.

***Hardy, Isaac E.,** Momence, Ill., Supt., Tiffany Enameled Brick Co.

Hare, Robert L., Upper Sandusky, Ohio, Mgr., Wyandot Clay Products Co.

***Harker, H. N.,** East Liverpool, Ohio, Pres., Harker Pottery Co.

Harker, O. A. Jr., Puryear, Tenn., Pres. and Mgr., Dixie Brick and Tile Co.

Harper, John L., Niagara Falls, N. Y., Hydraulic Power Co.

Harris, Marshall W., 227 East Park Place, Oklahoma City, Okla., Student, University of Illinois.

Harris, W. B., South Park, Ky., Supt., Coral Ridge Clay Products Co.

*__Harrop, Carl B.__, Lord Hall, Columbus, Ohio, Ohio State University.

*__Hart, Edward__, Easton, Pa., Professor of Chemistry, Lafayette College.

Hartford, Frank M., 99 Daniels St., Toronto, Ohio.

Hartmann, Miner L., 3006 McKoon Ave., Niagara Falls, N. Y., Director, Research Laboratory, Carborundum Co.

*__Harvey, F. A.__, Mount Union, Pa., United States Refractories Corp.

Harvey, George R., 448 Barton St., Hamilton, Ont., Canada, Vice-Pres. and Mgr., Canadian Hart Wheels, Ltd.

Harvey, Ives L., Bellefonte, Pa.

Harvey, J. Ellis, Orviston, Pa., Gen. Mgr., Centre Brick and Clay Co

*__Hasburg, John W.__, 1119 North LaSalle St., Chicago, Ill., Pres., John W. Hasburg Co., Inc.

Hasslacher, George F., Box 360, Cleveland, Ohio, Roessler & Hasslacher Chemical Co.

*__Hastings, Francis N.__, Hartford, Conn., Hartford Faience Co.

*__Hatton, Richard D.__, 1673 Railway Exchange Bldg., St. Louis, Mo., Vice-Pres. and Gen. Mgr., Laclede-Christy Clay Products Co.

Havas, A. B., 57 Rohrbacher St., Heidelberg, Germany, Consulting Chemist, Roessler & Hasslacher Chemical Co.

*__Haviland, Jean__, 32 Avenue du Midi, Limoges, France, Haviland & Co.

Hawke, C. E., Perth Amboy, N. J., Carborundum Co.

Hawley, W. S., Hanley, Stoke-on-Trent, England, George Howson & Sons, Ltd., Eastwood Sanitary Works.

Hayhurst, Walter, The Laund, Accrington, England.

Hays, George H., Cleveland, Ohio, Asst. Mgr., Vitreous Enameling Co.

Hazelwood, Fred, 310 "R" St., N. E., Washington, D. C.

Hazlehurst, Robert P., Old Bridge, N. J., Asst. Supt., Old Bridge Enameled Brick and Tile Co.

Healey, A. S., Elizabeth, N. J., Supt., Standard Sanitary Pottery Co.

Heath, Fred T., 4505 18th Ave. N. E., Seattle, Wash., Student, University of Washington.

Heinz, George P., The Heinz Roofing Tile Co., 1740 Champa St., Denver, Colo.

Heistand, Elza F., Muncie, Ind., Supt., Crucible Dept., Gill Clay Pot Co.

Helser, P. D., Flint, Mich., Ceramic Engineer, Champion Ignition Co.

Helwig, Frank J., 2411 Elizabeth St., Pueblo, Colo.

*Henderson, H. B., 1538 N. High St., Columbus, Ohio, Supt., Orton Pyrometric Cone Factory.

Henry, A. V., 111 West 2nd Ave., Columbus, Ohio.

*Henry, Frank R., Dayton, Ohio, Mgr., Dayton Grinding Wheel Co.

Henry, Kenneth M., San Francisco, Cal., Illinois Pacific Glass Co.

Henshaw, S. B., Charleston, W. Va., Asst. Gen. Mgr., Libbey-Owens Sheet Glass Co.

Hepler, I. F., 207 First National Bank Bldg., Tyrone, Pa., Chief Engineer, General Refractories Co.

*Hepplewhite, J. W., Mellon Institute, Pittsburgh, Pa., The Koppers Co.

Herrold, R. P., 955 Brighton Blvd., Zanesville, Ohio, Mosaic Tile Co.

Herron, James H., 1364 West Third St., Cleveland, Ohio, Consulting Engineer.

Herzog, John S., Newark, Ohio, Gen. Mgr., The Simpson Foundry and Engineering Co.

Hesler, N. A., Montreal, Canada, Gen. Mgr., Consumers Glass Co., Ltd.

*Hess, Henry W., 614 Stratford Place, Toledo, Ohio.

Hettinger, Edwin L., 1325 Mineral Spring Rd., Reading, Pa., Asst. Sec. and Purchasing Agent, T. A. Willson & Co., Inc.

Heuisler, Philip I., Baltimore, Md., Pres., Maryland Glass Corp.

Hewitt, L. C., 4928 a Itaska St., St. Louis, Mo., Chief Dispatcher, Laclede-Christy Clay Products Co.

Hibbins, Thomas A., Wellsville, Ohio, Gen. Business and Sales Mgr., The Stevenson Co.

Hibbs, Joseph S., 3203 West Columbia Ave., Philadelphia, Pa., Asst. Gen. Mgr., J. W. Paxson Co.

*Hice, Richard R., Beaver, Pa., State Geologist.

Hill, Charles W., Perth Amboy, N. J., Gen. Works Mgr., Atlantic Terra Cotta Co.

*Hill, Ercill C., Wissahickon Ave. and Juniata St., Philadelphia, Pa., Conkling-Armstrong Terra Cotta Co.

Hill, James H., 604-608 Pacific Electric Bldg., Los Angeles, Cal., Pres., Alberhill Clay and Coal Co.

Hinrichs, Carl G., 4112 Shenandoah Ave., St. Louis, Mo., Hinrichs Laboratories.

Hirano, Kosuke, Mantetsu Yogyo, Shiken Kojo, Dairen, Manchuria.

Hodges, R. T., 303 Railway Exchange Bldg., Chicago, Ill., Magnus Co.

Hodson, G. A., Loughborough, England, Managing Director, Hathern Station Brick and Terra Cotta Co., Ltd.

Hoehl, Joseph W., Box 367, Piqua, Ohio.

*Hoffman, George E., Trenton, N. J., Sales Mgr., The Trenton Potteries Co.

Hogensen, E. Jr., 1421-41 South 55th St., Cicero, Ill., Sec.-Treas., Chicago Vitreous Enamel Products Co.

Hogenson, William, 1421 So. 55th St., Cicero, Ill., Vice-Pres., Vitreous Enamel Products Co.

Hohnan, Ralph W., 402 Washington St., Peru, Ind., Gen. Foreman, Square D Co.

Holbert, John S., 7349 N. Paulina St., Chicago, Ill., Dist. Mgr., The Hardinge Co.

Holland, Job, Box 22, Sheffield, England.

Hollingsworth, C. M., Steubenville, Ohio, Ohio Valley Clay Co.

Hollmeyer, John G., 4226 Hazel Ave., Edgewater Station, Chicago, Ill., Sec.-Treas., American China Co.

Hollowell, R. D. T., 110 S. Dearborn St., Chicago, Ill., Sec., American Face Brick Association.

Holman, Harry B., 1017 Olive St., St. Louis Mo., Laclede Gas Light Co.

Holmes, J. C., Sandusky, Ohio, Supt., Sandusky Bulbs Works.

Holmes, M. E., 918 G St., N. W., Washington, D. C., Mgr. Chemical Dept., National Lime Association.

Holstein, L. S., Palmerton, Pa., Chief, Testing Dept., The New Jersey Zinc Co. (of Pa.).

*__Hood, B. Mifflin__, Atlanta, Ga., Pres., Mifflin Hood Brick Co.

*__Hope, Herford__, Fingringhoe, near Colchester, Essex, England, Colne Brick and Terra Cotta Co., Ltd.

*__Horning, Roy A.__, Lancaster, Pa., Mgr., Lancaster Brick Co.

*__Hornung, Martin R.__, 219 East St., Newcastle, Pa.

Hostetler, G. R., 704 Dartmouth St., N. W., Canton, Ohio.

*__Hostetter, J. C.__, Corning, N. Y., Physical Chemist, Corning Glass Works.

*__Hottinger, A. F.__, Chicago, Ill., Treas., Northwestern Terra Cotta Co.

Hoursouripe, J., Palentelen F. C. C. G. B. A., Republica Argentina.

Houser, A. T., S. 30th and Jane Sts., Pittsburgh, Pa., Mgr., Woods Lloyd Co.

Housman, Geo. S., 208 W. Fornance St., Norristown, Pa., Gen. Mgr., Lavino Refractories Co.

*__Howat, Walter L.__, Perth Amboy, N. J., Research Chemist, Atlantic Terra Cotta Co.

*__Howe, Raymond M.__, 507 S. Lang Ave., Pittsburgh, Pa., Mellon Institute.

Hower, H. S., Pittsburgh, Pa., Carnegie Institute of Technology, Physics Dept.

Hoyler, Fritz W., Perth Amboy, N. J., Works Mgr., Roessler & Hasslacher Chemical Co.

Hudson, Charles J., 39 Kingsbury St., Worcester, Mass., Special Investigator, Norton Co.

Huisken, H. A., 5000 Pacific Blvd., Vernon, Cal., The Vitrefrax Co.

*__Hull, W. A.__, Washington, D. C., U. S. Bureau of Standards.

*__Humphrey, Dwight E.__, 128 S. Fourth St., Cuyahoga Falls, Ohio, Sec., Portage Engineering Co.

*__Humphrey, Harold P.__, Washington, N. J., Washington Porcelain Co.

Hunt, Frank S., Beaver Falls, Pa., Beaver Falls Art Tile Co.

Hunt, Marsden H., 374 Ave. E, East Pittsburgh, Pa.

*__Hursh, Ralph K.__, Urbana, Ill., Ceramic Department, University of Illinois.

Ichijo, Mokiji, Lord Hall, Columbus, Ohio, Student, Ohio State University.

Ide, Kiyoshi, Amagasaki City, Japan, The Amagasaki Factory, Asahi Glass Co.

Iredale, George H., 2414 East Third St., Los Angeles, Cal., Whiting-Mead Commercial Co.

Irwin, Dewitt, East Liverpool, Ohio, Sec., Potters Supply Co.

*__Ittner, W. W.__, 5500 Pershing Ave., St. Louis, Mo., Treas., General Clay Products Corp.

Ivery, Sidney H., 4432 Gibson Ave., St. Louis, Mo., Enamel Plant Supt., Hydraulic Press Brick Co.

*__Jackson, C. E.__, Wheeling, W. Va., Pres., Warwick China Co.

Jackson, Frederick G., Columbus, Ohio, Asst. Chemist, U. S. Bureau of Mines.

Jackson, H. W., Cambridge, Ohio, Guernseyware Co.

Jackson, Wynne L., 111 S. Kilpatrick Ave., Chicago, Ill.

*__Jacobs, W. M.__, Charleroi, Pa., Pittsburgh Plate Glass Co.

Jacobsen, Carl, 7 Malmogade, Copenhagen, Denmark, Professor of Ceramics, Technical High Schbol.

Jacquart, Chas. E., South River, N. J., American Enameled Brick Co.

*__Jaeger, Frank G.__, 10th and Mullanphy Sts., St. Louis, Mo., Vice-Pres. and Gen. Mgr., Superior Enamel Products Co.

James, W. Roy, 118 W. 14th St., Marion, Ind., Bethevan Factory, Macbeth-Evans Glass Co.

*__Jeffery, Joseph A.__, Detroit, Mich., Pres., Champion Porcelain Co.

Jeffery, L. Edson, Detroit, Mich., Champion Porcelain Co.

Jenks, H. P., 614-615 Commerce Bldg., Cor. High and Spring Sts., Columbus, Ohio, Hook Patent Kiln Co.

Jensen, James L., 156 Green St., Brooklyn, N. Y., Asst. Mgr., Empire China Works.

*__Jeppson, George N.__, Worcester, Mass., Sec. and Works Mgr., Norton Co.

Jewett, Fred E., Muncie, Ind., Gen. Supt., Ball Bros. Glass Mfg. Co.

Jewett, Richmond, Lackawanna, N. Y., Supt., Jewett Refrigerator Co.

Johnson, A. A. V., 1137 W. 78th St., Chicago, Ill., L. E. Rodgers Engineering Co.

Johnson, Joseph, Trenton Potteries Co., Trenton, N. J., Chemist, Research Division.

Johnson, William, 207 St. James St., Montreal, Canada, Pres., Canadian Non-Metallic Minerals, Ltd.

Johnson, William J., 4148 Langland St., Cincinnati, Ohio, Clay Salesman, National Sales Co.

***Johnston, John,** 245 East Rock Road, New Haven, Conn.

Johnston, Robert M., Kenova, W. Va., Ceramic Engineer, Jeffery-Dewitt Insulator Co.

Jones, Benjamin C., Pittsfield, Mass., Pittsfield Porcelain Works of General Electric Co.

Jones, Cecil, Maurer, N. J., American Encaustic Tiling Co.

***Jones, Chester H.,** 1570 Old Colony Bldg., Chicago, Ill., Industrial Editor, "Chemical and Metallurgical Engineering."

Jones, John Edward, 28 Vine St., Trenton, N. J., Trenton Potteries Co.

Jones, Otis L., Ogelsby, Ill., Pres. and Mgr., Illinois Clay Products Co.

Jones, Richard E., 904 Lock St., Tarentum, Pa., Pittsburgh Plate Glass Co.

***Jones, Robert W.,** Geologist, Catskill, N. Y.

Jones, Walter A., 50 So. Third St., Columbus, Ohio, Pres., W. R. Jones & Co.

Justice, Ithamar M., Dayton, Ohio, Vice-Pres., Manufacturers' Equipment Co.

Kahn, Bertrand B., Hamilton, Ohio, Sec. and Gen. Works Mgr., Estate Stove Co.

Kahn, Harry J., 1218 Wheeler St., New York City.

Kahn, Isaac, 2428 Reading Rd., Cincinnati, Ohio, Owner, Wheatley Pottery Co.

***Kalbfleisch, G. C.,** Tiffin, Ohio, Mgr., Standard Sanitary Mfg. Co.

Kallstedt, C. H., 72 W. Adams St., Chicago, Ill., Industrial Gas Engineer.

Kanashima, Shigeta, Tokyo Technical College, Asakusa, Tokyo, Japan.

Kanengeiser, Fred R., Poland, Ohio.

Karan, William, 136 Gould St., Beaver Dam, Wis., Monarch Malleable Iron Range Co.

***Karzen, Samuel C.,** Arctic and Kalmia Sts., San Diego, Cal., Standard Mfg. Co.

Kato, Mitsu, Uno-ko, Okayamaken, Japan, Managing Director, Uno Fire Brick Co.

Kawai, Kozo, Inbe, Wakegun, Okayamaken, Japan, Kyushu Fire Brick Co.

Kebler, Leonard, Mt. Vernon, N. Y., Ward-Leonard Electric Co.

Keehn, Clarence C., Canandaigua, N. Y., Pres. and Gen. Mgr., Lisk Mfg. Co. Ltd.

*Keele, J., Ottawa, Canada, Department of Mines, Mines Branch.

Keenan, James T., Parkersburg, W. Va., Supt., Vitrolite Co.

Keenan, John F., 1147 20th Ave. N., Seattle, Wash., Gen. Mgr., Denny-Renton Clay and Coal Co.

Keese, A. W., 1312 E. 112th St., Cleveland, Ohio, Gen. Supt., Collinwood Shale Brick and Supply Co.

Kelkar, G. D., 847 Sadashive peth, Poona City, Bombay presidency, India.

Kelly, M. J., 88 Van Dyke St., Brooklyn, N. Y., Vice-Pres. and Mgr., Brooklyn Fire Brick Works.

Kempf, John R., Detroit, Mich., Detroit-Star Grinding Wheel Co.

Kendrick, Lucius S., 513 Bearinger Bldg., Saginaw, Mich., Vice-Pres. and Gen. Mgr., Central Michigan Clay Products Co.

Kennedy, John H., 114 Hubbel St., Canandaigua, N. Y., Asst. Supt., Lisk Mfg. Co. Ltd.

*Kent, G. G., 241 Cavalry Ave., Detroit, Mich., Detroit-Star Grinding Wheel Co.

Kenyon, S. Spicer, 321 First St., Niagara Falls, N. Y., Carborundum Co.

*Keplinger, Robert B., Canton, Ohio, Asst. Gen. Supt., Metropolitan Paving Brick Co.

Ker, Severn R. Jr., Sharon Steel Hoop Co., Sharon, Pa.

*Kerr, C. H., 342 East 2nd St., Moorestown, N. J., DeZeng-Standard Co., Camden, N. J.

*Kerr, W. B., Syracuse, N. Y., Pres., Iroquois China Co.

Keuffel, Carl W., Adams and Third Sts., Hoboken, N. J., Keuffel & Esser Co.

Khosla, Jamnadas, 4617 Center Ave., Pittsburgh, Pa., Student, University of Pittsburgh.

*Kier, S. M., 2243 Oliver Bldg., Pittsburgh, Pa., Pres., Kier Fire Brick Co.

Kimberling, Henry R., 5034a Arsenal St., St. Louis, Mo., Foreman, Blackmer & Post Pipe Co.

*Kimble, Herman K., Vineland, N. J., Mgr., Scientific Glass Department, Kimble Glass Co.

King, Earl O., Box 190, Baltimore, Md., American Refractories Co.

King, Walter A., Elyria, Ohio, Asst., Enamel Research Laboratory, Elyria Enameled Products Co.

*Kingsbury, Percy C., 50 Church St., New York City, Chief Engineer, General Ceramics Co.

*Kirk, Charles J., New Castle, Pa., Pres. and Gen. Mgr., Universal Sanitary Mfg. Co.

Kirk, H. S., New Castle, Pa., Sec., Universal Sanitary Mfg. Co.

***Kirkpatrick, F. A.**, Kenova, W. Va., Jeffery-Dewitt Insulator Co.

Kitamura, Y., Kyoto, Japan, Director and Chief Engineer, Shofu Kogo Kafushiki Kaisha, (Shofu Industrial Co. Ltd.)

Klaesius, Paul K., 3350 Scotten Ave., Detroit, Mich., Factory Supt., Wolverine Porcelain Enameling Co.

***Klein, A. Albert**, Worcester, Mass., Research Laboratory, Norton Co.

Klein, Gordon, Springfield Paving Brick Co., Springfield, Ill., Ceramic Engineer.

Kleinfeldt, Henry F., 220 Broadway, New York City, Secretary, Abbé Engineering Co.

Kline, Z. C., Central Falls, R. I., National Lamp Works.

***Klinefelter, T. A.**, Box 317, Tottenville, Staten Island, N. Y., Atlantic Terra Cotta Co.

Kneisel, Carl F., Sheridan, Wyo., Sec.-Treas. and Mgr., Sheridan Press Brick and Tile Co.

***Knight, M. A.**, East Akron, Ohio.

***Knollman, H. J.**, 116 N. Paxon St., Philadelphia, Pa., The Abrasive Co.

***Knote, J. M.**, (Address unknown)

Knowles, H. H., Santa Clara, Cal., Pres., The Homer Knowles Pottery Co.

Knowles, W. V., Peoples Gas Bldg., Chicago, Ill., Dist. Mgr. and Technical Representative, Titanium Alloy Mfg. Co., Buckman and Pritchard Inc.

Knudsen, Rolf, Borgestad, Norway, Borgestad Chamottefabrik.

Koch, Arthur L., 1898 Berkeley Ave., St. Paul, Minn.

Koch, Chas. F., Cincinnati, Ohio, The National Sales Co.

Koering, E. W., Crystal Ave., Vineland, N. J., Department Foreman, Kimble Glass Co.

Koerner, Walter E., Harrison, N. J., Chief Glass Chemist, Edison Lamp Works.

Kohler, Anthony M., 85 Liberty St., New York City, Mechanical Engineer, The Babcock & Wilcox Co.

***Kohler, Walter J.**, Kohler, Wis., Pres., J. M. Kohler Sons Co.

Kondo, S., Tokyo Higher Technical School, Tokyo, Japan.

Koos, E. K., New Cumberland, W. Va., Chelsea China Co.

Koupal, Walter G., Creighton, Pa., Chemist, Pittsburgh Plate Glass Co.

Krak, J. B., 42 Hammond St., Jamaica, N. Y., Technical Editor, "The Glass Industry."

Kraner, Hobart M., 61 Welch Ave., Columbus, Ohio, U. S. Bureau of Mines.

Kraus, Charles E., 66 87th St., Brooklyn, N. Y.

Kraus, Louis P. Jr., East Liverpool, Ohio, Vice-Pres., Kraus Research Laboratories, Inc.

Kraus, Lysle R., 159 Forest Ave., West Englewood, N. J., Sec., Kraus Research Laboratories, Inc.

Krause, George, R. F. D. 1, Zanesville, Ohio.

Krebs, A. E., South 16th St., Belleville, Ill., Belleville Enameling Works.

Kreger, John M., Woodbridge, N. J., Woodbridge Ceramic Corp.

*__Krehbiel, Junius F.__, 1538 N. High St., Columbus, Ohio, Orton Pyrometric Cone Factory.

Kreitzer, Henry R., 277 Hawthorne Ave., Portland, Ore., Sec., Columbia Brick Works.

Krekel, Albert, 1917 W. Fayette St., Baltimore, Md., Engineer, Porcelain Enamel and Manufacturing Co.

*__Krick, George M.__, Decatur, Ind., Gen. Mgr., Krick, Tyndall & Co.

*__Krusen, I. Andrew__, Danville, Ill., American Refractories Co.

Krusen, Joseph H., A. P. Green Fire Brick Co., Mexico, Mo.

Kurahashi, T., P. O. Terasho, Shigaken, Japan.

*__Kurtz, John C.__, Rochester, N. Y., Bausch & Lomb Optical Co.

Kurtz, Thos. N., Claysburg, Pa., Standard Refractories Co.

Lacy, Mattie Lee, Denton, Texas, College of Industrial Arts.

Laird, Charles, 4956 McPherson St., St. Louis, Mo.

Laird, Clinton N., Canton, China, Professor of Chemistry, Canton Christian College.

*__Laird, J. S.__, 315 Jefferson St., Charleston, W. Va., Champion Porcelain Co.

*__Lambie, J. M.__, Washington, Pa., Vice-Pres. and Gen. Mgr., Findlay Clay Pot Co.

Lamborn, Lloyd, 118 East 28th St., New York City, Editor, "Chemical Age."

*__Lamont, R. A. Jr.__, Salem, Ohio, Gen. Mgr., National Sanitary Co.

*__Landers, Wm. F.__, Indianapolis, Ind., Supt., U. S. Encaustic Tile Works.

*__Landrum, R. D.__, 2645 Ashton Rd., Cleveland, Ohio, Vice-Pres., The Vitreous Enameling Co.

__Langenbeck, Karl__, 1625 Hobart St. N. W., Washington, D. C.

Langworthy, H. S., Jewettville, N. Y., Vice-Pres. and Supt., Jewettville Clay Products Co.

Lapp, G. W., LeRoy, N. Y., Electrical Engineer, Lapp Insulator Co.

Lardin, R. H., Creighton, Pa., Pittsburgh Plate Glass Co.

*__Larkin, Paul G.__, Box 92, Lincoln, Cal., Gladding, McBean & Co.

Larkins, Samuel B., Salineville, Ohio, Supt., National China Co.

Larson, Gustaf, 503 Security Bldg., Los Angeles, Cal., Los Angeles Brick Co.

Lasley, Marshall, 801 Volunteer Bldg., Chattanooga, Tenn.

Lauer, Frank E., Cowansville, Quebec, Canada, The W. F. Vilas Co. Ltd.

Laughlin, Samuel O., Wheeling, W. Va., Pres. and Gen. Mgr., Wheeling Tile Co.

Lawler, John J., 839 Thomas Ave., Forest Park, Ill., Salesman, Jas. H. Rhodes & Co.

Lawrence, George J., 7709 S. Morgan St., Chicago, Ill., Field Mgr., The J. B. Ford Co.

Lawson, Carl H., Bacon St., Waltham, Mass., Waltham Grinding Wheel Co.

Lawson, George G., 2525 Clybourn Ave., Chicago, Ill., Northwestern Terra Cotta Co.

Lawton, Lewis H., Trenton, N. J., Sec. and Gen. Mgr., Jonathan Bartley Crucible Co.

Lax, Frederick, Hunslet, Leeds, England, Albert Glass Works.

Lax, Thomas, Hunslet, Leeds, England, Clarence Glass Works.

*__Layman, Frank E.__, Milwaukee, Wis., Cutler-Hammer Co.

Lee, P. William, 395 14th Ave., Columbus, Ohio.

Leibson, J. S., 15 Robinson Rd., Shanghai, China, China General Edison Co.

Lemley, W. E., Taylor, Wash., Supt., Denny-Renton Clay and Coal Co.

Levings, G. v. B., Box 86, Seneca, Newton Co., Mo., Resident Mgr., American Tripoli Co.

Leyerle, Arthur R., 3595 West 47th St., Cleveland, Ohio.

*__Libman, Earl E.__, Urbana, Ill., Ceramic Department, University of Illinois.

*__Lillibridge, H. D.__, Zanesville, Ohio, American Encaustic Tiling Co.

Limberg, Frank, Box 505, Cincinnati, Ohio, Gen. Mgr., Limberg Enameling Works.

Lin, C. C., 31 Inside Grand East Gate, Shanghai, China.

*__Linder, Cyril S.__, Creighton, Pa., Pittsburgh Plate Glass Co.

Lindley, Jacob, Tiltonville, Ohio, Riverside Potteries Co.

Lindmueller, Charles, East Chicago, Ind., Supt., Metal and Thermit Corp.

Lindsay, George W., Denver, Colo., Factory Supt., Denver Fire Clay Co.

Lindsay, R. D., W. 16th Ave. and Clay St., Denver, Colo., Supt., The Denver Pressed Brick Co.

Ling, S. C., 562 Medhurst Road, Shanghai, China.

Lintz, E. H., Lackawanna, N. Y., Jewett Refrigerator Co.

Lippert, Charles G., 610 Crest Ave., Charleroi, Pa., Macbeth-Evans Glass Co.

Lippert, Walter T., 1322 E. Broadway, Alton, Ill., Illinois Glass Co.

Little, E. C., 1673 Railway Exchange Bldg., St. Louis, Mo., Asst. Sales Mgr., Laclede-Christy Clay Products Co.

Little, H. B., Baltimore, Md., Pres., Baltimore Enamel and Novelty Co.

Liu, S. Y., 19 Harrison Ave., Boston, Mass.

Llige y Pages, Juan, 304 Consejo de Ciento St., Barcelona, Spain.

Lloyd, A., Washington, Pa., Supt., Hazel Factory No. 2, Hazel-Atlas Glass Co.

Locke, F. M., Victor, N. Y.

Long, R. N., Woodbridge, N. J., Federal Terra Cotta Co.

*__Longenecker, H. L.__, Cambridge, Md., Mgr., Cambridge Brick Co.

*__Loomis, George A.__, Steubenville, Ohio, Ohio Valley Clay Co.

Lord, F. G., 341 Fourth Ave., Pittsburgh, Pa., Pennsylvania Pulverizing Co.

Lord, N. W. Jr., 338 W. 8th Ave., Columbus, Ohio, Student, Ohio State University.

Louthan, Wm. B., East Liverpool, Ohio, Mgr., Louthan Supply Co.

Lovatt, John, 1308 Brunswick Bldg., Trenton, N. J., Kiln Builder.

Love, Herbert G., 207 Hammond Bldg., Moose Jaw, Sask., Canada, Dominion Fire Brick & Clay Products Co. Ltd.

*__Lovejoy, Ellis__, 480 W. 6th Ave., Columbus, Ohio, Mgr., Lovejoy Engineering Co.

Lucas, Herbert L., Champaign, Ill., Student, University of Illinois.

*__Lucas, H. J.__, 2525 Clybourn Ave., Chicago, Ill., Northwestern Terra Cotta Co.

Ludlum, Bert A., Noblesville, Ind., Mgr., Union Sanitary Works.

Luepke, Emil J., 2001 S. Kings Highway, St. Louis, Mo., Foreman, Quick Meal Stove Co.

Luter, Clark A., 401-4 Lobe Bldg., South Gay St., Baltimore, Md., Consulting Ceramist.

Lynch, Richard H., 8th and O'Donnell Sts., Baltimore, Md.

Lyon, J. Boyd, St. Louis, Mo., Laclede-Christy Clay Products Co.

Lyon, P. W., 1332 Frick Bldg., Pittsburgh, Pa., Special Representative, American Sheet and Tin Plate Co.

Lyons, Chas. E., Kenova, W. Va., Supt. of Productions, Jeffery-Dewitt Insulator Co.

McAllister, James E., Trenton, N. J., Ceramist, J. L. Mott Co.

*__McBean, Atholl__, 311-317 Crocker Bldg., San Francisco, Cal., Gladding, McBean & Co.

McCauley, George V., Corning, N. Y., Physicist, Corning Glass Works.

McClafferty, Harry J., 2124 Andrews St., Rockford, Ill., Supt., Rockford Vitreous Enamel Co.

*__McCoy, William__, 334 Adair Ave., Zanesville, Ohio, Mechanical Engineer, American Encaustic Tiling Co.

*__McDanel, Walter W.__, 532 Thirteenth Ave., New Brighton, Pa.

*__McDougal, Taine G.__, Flint, Mich., Champion Ignition Co.

***McDowell, J. S.**, Pittsburgh, Pa., Research Dept., Harbison-Walker Refractories Co.

McDowell, S. J., Flint, Mich., Ceramic Engineer, Champion Ignition Co.

***McElroy, R. H.**, Dayton, Ohio, International Clay Machinery Co.

McGean, Ralph L., Harshaw Fuller & Goodwin Co., 545 Hanna Bldg., Cleveland, Ohio.

McGee, Earle N., Syracuse, N. Y., Research Laboratory, Semet-Solvay Co.

McHose, Malcolm M., Perth Amboy, N. J., Mgr., L. H. McHose Inc.

McKaig, W. Wallace, Cumberland, Md., McKaig Machine Foundry and Supply Works.

McKelvey, John H., St. Louis, Mo., Sales Mgr., Laclede-Christy Clay Products Co.

***McKinley, J. M.**, Curwensville, Pa., Crescent Refractories Co.

McLaughlin, John, Box 31, Tiltonville, Ohio, Wheeling Sanitary Mfg. Co.

MacMichael, P. S., Auburn, Wash., Pres., Northern Clay Co.

McMillan, H. B., Lincoln, Cal., Asst. Ceramic Chemist, Gladding, McBean & Co.

McMillan, Herbert S., Detroit, Mich., Sec. and Mgr., Porcelain Enameling and Mfg. Co.

McNeil, Daniel W., 2374 Mound Ave., Norwood, Ohio, Gen. Supt., The John Douglas Co., Cincinnati, Ohio.

McVay, T. M., Kenova, W. Va., Basic Products Co.

Mackenzie, Wm. G., 702 W. 24th St., Wilmington, Del., Golding Sons Co.

Mackie, I. C., Sydney, Nova Scotia, Dominion Iron and Steel Co.

***Maddock, A. M. Jr.**, Trenton, N. J., Thomas Maddock & Sons.

Maddock, Charles S. Jr., Trenton, N. J., Works Mgr., Thos. Maddock Sons Co.

***Maddock, Henry E.**, Trenton, N. J., John Maddock & Sons.

Maddock, John B., Trenton, N. J., John Maddock & Sons.

Madeira, Crawford C., 900 North American Bldg., Philadelphia, Pa., Maderia Hill & Co.

Mahoney, Frank B., Crane Enamel Ware Co., Chattanooga, Tenn., Asst. Supt.

Malborn, Joseph, 634 S. Homewood Ave., Warren, Ohio, Asst. Gen. Supt., Sharon Steel Hoop Co.

Maley, William V., 315 W. Maryland Ave., Sebring, Ohio, Foreman, Limoges China Co.

Malinovszky, A., 316 Portland Ave., Belleville, Ill., U. S. Smelting Furnace Co.

Malkin, William R., Box 669, Wheeling, W. Va.

Mallory, J. M., Savannah, Ga., Gen. Industrial Agt., Central of Ga. Railway Co.

*Malm, Arthur T., 18 Orne St., Worcester, Mass., Norton Co.

*Malsch, Werner, 709-717 Sixth Ave., New York City, Ceramic Dept., Roessler & Hasslacher Chemical Co.

*Maltby, Alfred, 70 East 3rd St., Corning, N. Y., Supt., Corning Brick Terra Cotta and Tile Co.

Mandle, I., 1318 Wright Bldg., St. Louis, Mo., Sec.-Treas., Mandle Clay Mining Co.

Mandle, Sidney R., Whitlock, Tenn., Asst. Treas., Mandle Clay Mining Co.

*Manion, L. W., 1370 Greenfield Ave. S. W., Canton, Ohio.

Mann, Thomas S., 695 Sherlock Ave., Portland, Ore., Mgr., Pacific Stoneware Co.

Manor, John M., East Liverpool, Ohio, Mgr., Golding Sons Co.

Manson, Mahlon E., Milwaukee, Wis., Chemist, Rundle Mfg. Co.

Marks, Melville, 29 Broadway, New York City, Moore & Munger.

Marquette, John R., Belle, Mo., President Marquette Mining Co.

Marsh, Henry S., Youngstown, Ohio, Sharon Steel Hoop Co.

Marshall, S. M., 121 Madison Ave., New York City.

*Marson, Percival, Whinhouse, Sydney Terrace, Craigentinny, Edinburgh, Scotland, Webbs' Crystal Glass Co., Ltd.

*Martens, Paul, Chrome, N. J., Metal and Thermit Corp.

Martin, Earle V., Forest Grove, Ore., Forest Grove Clay Products Co.

Martin, Leonard A., 2212 East Lake Ave., Seattle, Wash., Chemist, Denny-Renton Clay and Coal Co.

Martin, S. C., Kittanning, Pa, Kittanning Brick and Fire Clay Co.

*Martz, Joseph A., 18th and Clark Sts., Wellsville, Ohio, McLain Fire Brick Co.

Maruyama, Junkichi, 7 Icchome, Gojotori, Chikko, Osaka, Japan.

Mauschbaugh, Henry J., 806 Linn St., Peoria, Ill., Carter's Brick Yard No. 2.

*Mayer, A. E., Mayer China Co., Beaver Falls, Pa.

*Maynard, T. Poole, 1321 Hurt Bldg., Atlanta, Ga., Consulting Geologist.

Meissner, Max, 201 E. Chestnut St., Hoopeston, Ill., Enameler, Sprague Canning Machine Co.

*Mellor F. G., New Castle, Pa., Shenango Pottery Co.

*Mellor, J. W., Sandon House, Regent St., Stoke-on-Trent, England.

Memory, N. H., 46 Bridge St., Newark, N. J., Engineer, Isbell-Porter Co.

Menne, L. H., 977 N. Main St., Rockford, Ill., George D. Roper Corp.

Merica, Paul D., Bayonne, N. J., Supt. of Research, International Nickel Co.

Merritt, L. M., 586 E. Long St., Columbus, Ohio, Ceramic Engineer, Barnbey-Cheney Engineering Co.

Metz, G. F., 120 Broadway, New York City, Sales Engineer, Hardinge Co.

*__Metzner, Otto__, Cincinnati, Ohio, Supt. of Manufacture, Rookwood Pottery Co.

Middleton, George, 165 Broadway, New York City, Patent Attorney.

Middleton, Jefferson, 1329 Randolph St. N. W., Washington, D. C., Statistician, U. S. Geological Survey.

Milford, L. R., Syracuse, N. Y., Laboratory Mgr., The Solvay Process Co.

Miller, Donald M., 633 Monmouth St., Trenton, N. J., Sec., Crossley Machine Co.

Miller, Emerson R., Zanesville, Ohio, Salesman, Mosaic Tile Co.

Miller, Julius J., (Address unknown).

Miller, J. Walter, 634 Forest Ave., Zanesville, Ohio, Mechanical Engineer, Mosaic Tile Co.

Milligan, Frank W., Parkersburg, W. Va., Mgr., General Porcelain Co.

Mills, George P., 908 Chestnut St., Philadelphia, Pa., Electrical Engineer, Electric Furnace Construction Co.

Minehart, A. G. Jr., Toledo, Ohio, The Rock Products Co.

*__Miner, Harlan S.__, Gloucester City, N. J., Chemist, Welsbach Co.

Minter, Maurice M., 922 Broad St., Columbus, Ga., The Minter System.

Minton, C. R., Box 14, Seville, Ohio.

Minton, G. Z., Creighton, Pa., Ceramic Engineer, Pittsburgh Plate Glass Co.

*__Minton, R. H.__, Metuchen, N. J., Gen. Supt., General Ceramics Co.

Misumi, Aizo, Marunouchi, Tokyo, Japan, Asahi Glass Co.

Mitchell, Henry J., 4547 Montclair Ave., Detroit, Mich., Champion Porcelain Co.

Mitchell, Leon W., (Address unknown).

Mitscherling, W. O., Landing, N. J., Atlas Powder Co.

Modes, Chas. H., 1602 Henry St., Alton, Ill., Illinois Glass Co.

Moellering, Walter S., 414 Montgomery St., Fort Wayne, Ind., Wm. Moellering's Sons.

Momoki, Saburo, Sanbonmatsu, Kokura, Kyushu, Japan, Ceramic Engineer.

Moncrieff, James W., 428 E. Pine St., Stockton, Cal.

Montag, Harry A., 883 Commercial St., Portland, Ore., Supt., Montag Stove Works.

*__Montgomery, E. T.__, Franklin, Ohio, Pres. and Gen. Mgr., Montgomery Porcelain Products Co.

Montgomery, J. C., Sebring, Ohio, Supt., Limoges China Co.

Montgomery, R. A., 213 Second St., Niagara Falls, N. Y., Carborundum Co.

*Montgomery, Robert J., Rochester, N. Y., Bausch & Lomb Optical Co.

Moore, Earl J., Bldg. Y-7, Camp Sherman, Ohio.

Moore, E. S., State College, Pa., Dean, School of Mines, Pennsylvania State College.

*Moore, H. W., 8300 Torresdale Ave., Holmesburg, Philadelphia, Pa., Precision Grinding Wheel Co.

*Moore, Joseph K., 122 Waverly Place, New York City, Consulting Ceramic and Production Engineer, Sanderson & Porter.

*Morey, George W., 2801 Upton St., Washington, D. C., Geophysical Laboratory.

Morley, S. I., 246 E. Ohio Ave., Sebring, Ohio, Sales Mgr., Sebring Pottery Co.

Moroney, John J., 2825 W. Harrison Ave., Chicago, Ill.

Morris, Bert W., 5049 Murdock Ave., St. Louis, Mo., Supt., Parker Russell Mining & Mfg. Co.

*Morris, George D., 413 Hillcrest Ave., New Castle, Pa., Supt., New Castle Refractories Co.

Morris, Paul R., 300 East 9th Ave., Tarentum, Pa., Chemist, Pittsburgh Plate Glass Co.

Morrow, Robert P., 1513 Rockefeller Bldg., Cleveland, Ohio, Salesman, Harbison-Walker Refractories Co.

Moss, Lester M., Harrison, N. J., Supt., Harrison Bulb Works of General Electric Co.

*Mossman, P. B., Box 1122, Pittsburgh, Pa., Vice-Pres. and Treas., American Refractories Co.

Motz, W. H., Akron, Ohio, Sec. and Treas., Colonial Sign and Insulator Co.

Moulton, D. A., Iowa State College, Ames, Iowa, Dept. of Ceramic Engineering.

*Muckenhirn, Charles H., 550 Chalmer Ave., Detroit, Mich., Representative, Standard Sanitary Mfg. Co.

Muessig, C. Nick, Box 267, East Liverpool, Ohio, Salesman, B. F. Drakenfeld & Co., Inc.

Mulholland, V., 41 Arch St., Hartford, Conn.

Mumma, C. M., Lock Box E, Haviland, Ohio, Haviland Clay Works.

Munroe, L. J., 912 Colborne St., London, Ont., Canada, Chief, Enamel Dept., McClary Mfg. Co.

*Munshaw, L. M., Terra Cotta, Ill., Ceramist, American Terra Cotta and Ceramic Co.

Murai, Shioichiro, Mantetsu Yogyo, Shiken, Kojo, Dairen, Manchuria.

Musiol, Charles, 16 rue de la Bigorne, Brussels, Belgium, Engineer.

Myers, Charles H., 498½ Poplar St., Murray, Utah, Supt., Utah Fire Clay Co.

Myers, Elmer E., Brookville, Pa., Brookville Glass and Tile Co.

Myers, Scott P., Uhrichsville, Ohio, Uhrichsville Clay Co.

Naganuma, Hikosaburo, Kamoike Works, Kagoshima, Japan, Engineer, Kagoshima Electric Railroad Co.

Nagle, J. A., 196 Oak St., Columbus, Ohio.

Nagle, Michael F., 210 John St., South Amboy, N. J., Supt., South Amboy Terra Cotta Co.

Namba, Motohiro, Asahi Glass Co., Tokyo, Japan.

Navias, Louis, 203 Ceramics Bldg., Urbana, Ill., University of Illinois.

Nelson, L. C., Peru, Kansas, Mgr., Mid-Continent Clay Co.

Niblock, Charles, Zanesville, Ohio, American Encaustic Tiling Co.

Nickerson, F. P., 8100 Broadway, Cleveland, Ohio, Engineer, W. S. Tyler Co.

Niegsch, Paul H., Scranton Enameling Co., Scranton, Pa., Mgr.

Niemura, Nobutaro, 1197 Nanba-Ashiwaracho, Minamiku, Osaka, Japan, Nishimura Chemical Ceramic Laboratory.

Nies, Frederick H., Corner of Hamilton Ave. and Summit St., Brooklyn, N. Y.

Niles, Glenn H., 24 State St., New York City, Engineer, Improved Equipment Co.

Nolan, C. J., Toledo, Ohio, Gen. Mgr., Modern Glass Co.

Norwood, George M., Raleigh, N. C., Pres., George M. Norwood Brick Co.

Nye, C. P., Uniontown, Pa., Mgr., Richmond Radiator Co.

Oakley, Walter W., 32 E. Second St., Corning, N. Y., Corning Glass Works.

O'Brian, Brian, Buffalo, Kan., Asst. Supt., Buffalo Brick Co.

Odelberg, A. W., Gustafsberg, Stockholm, Sweden.

Oesterle, Henry, 375 South Main St., Canandaigua, N. Y.

Offill, Paul M., 901 Oliver Bldg., Pittsburgh, Pa., Dist. Mgr., Laclede-Christy Clay Products Co.

Ogale, G. P., Mellon Institute, Pittsburgh, Pa.

Ogden, D. P., Streator, Ill., Engineer, Streator Brick Co.

*__Ogden, Ellsworth P.,__ 1957 Chelsea Rd., Columbus, Ohio, J. B. Owens Tunnel Kilns Co.

O'Hara, Eliot, 46 Greenwood Lane, Waltham, Mass., Mgr., O'Hara Waltham Dial Co.

Okura, K., 84 Kobayashi-Cho, Nagoya, Japan, Managing Director, Japan Porcelain Corp.

O'Leary, T. A., 1212 Keenan Bldg., Pittsburgh, Pa., Pres., T. A. O'Leary Co., Inc., and Enid Clay Co., Inc.

Olsen, Peter C., 150 Nassau St., New York City.

Openhym, George J., 352 Riverside Drive, New York City.

Orrell, John, Thorold, Ont., Canada, Chief Chemist, Pilkington Brothers.

*__Ortman, Fred B.,__ Glendale, Cal., Tropico Potteries, Inc.

*__Orton, Edward, Jr.,__ 1538 N. High St., Columbus, Ohio.

*Oudin, Charles P., 2327 Pacific Ave., Spokane, Wash., Pres. and Mgr., American Fire Brick Co.

Overbeck, Elizabeth G., Cambridge City, Ind., Overbeck Pottery.

Owens, F. W., 654 W. Franklin St., Baltimore, Md.

*Owens, Francis T., Watsontown, Pa., Factory Mgr., Fiske & Co., Inc.

Owens, J. B., Zanesville, Ohio.

Page, H. E., 15 Robison Rd., Shanghai, China, Managing Director, China General Edison Co., Inc.

Parker, George W., 1624 Railway Exchange Bldg., St. Louis, Mo., Vice-Pres. and Gen. Mgr., Russell Engineering Co. of St. Louis.

*Parker, Lemon, 3314 Morganford Rd., St. Louis, Mo., Vice-Pres. and Supt., Parker-Russell Mining and Mfg. Co.

Parkinson, Caleb, Ashdale, Holmfield, Halifax, Yorkshire, England, Mgr., Messrs. Parkinson & Spencer Ambler Thorn Fireclay Works.

Parkinson, J. C., 704 Third Ave., Tarentum, Pa., Chemist, Pittsburgh Plate Glass Co.

*Parmelee, C. W., University of Illinois, Urbana, Ill., Ceramic Engineering Department.

Parr, John R., 224 Sinclair Pl., Westfield, N. J., Mgr., Sanitary Porcelain Dept., General Ceramics Co.

*Pass, R. H., Syracuse, N. Y., Onondaga Pottery Co.

*Paterson, Alexander, Clearfield, Pa., Pres., Paterson Fire Brick Co.

Patten, D. M., Chattanooga, Tenn., Treas., Chattanooga Stamping and Enameling Co.

Paul, Joseph R., Newark, Cal., Enamel Foreman, Graham Mfg. Co.

Paul, William W., 1550 W. Euclid St., Detroit, Mich., Supt., Wolverine Porcelain Enameling Co.

Paulsen, Carl A., 45 Smallegade, Copenhagen, F, Denmark.

*Payne, A. R., Clarksburg, W. Va., Chief Physicist, Hazel-Atlas Glass Co.

Pearson, Howard L., Mexico, Mo., Engineer, A. P. Green Fire Brick Co.

*Peck, Albert B., Ann Arbor, Mich., Mineralogical Laboratory, University of Michigan.

Pellerano, Silvio, 1837 71st St., Brooklyn, N. Y., Asst. Chemist, Hemming Mfg. Co.

Pelton, Herbert E., 844 Fifth Ave., Los Angeles, Cal., Sec.-Treas., West Coast Tile Co., Inc.

*Pence, F. K., East Liverpool, Ohio, Knowles, Taylor & Knowles.

Pendrup W., Cicero, Ill., Supt., Enameling Dept., Coonley Mfg. Co.

Penfield, L. W., Bucyrus, Ohio, Hadfield-Penfield Steel Co.

Penfield, R. C., 1619 Conway Bldg., Chicago, Ill., Hadfield-Penfield Steel Co.

*Peregrine, C. R., Chamber of Commerce Bldg., Pittsburgh, Pa., Macbeth-Evans Glass Co.

Perg, Carl, 609 W. Kalamazoo Ave., Kalamazoo, Mich.

Perry, Henry W. B., 4600 South Kings Highway, St. Louis, Mo., Supt., Christy Plant, Laclede-Christy Clay Products Co.

*Pettinos, George F., 305 N. 15th St., Philadelphia, Pa., Senior Partner, Pettinos Brothers.

Pfalzgraf, Charles F., Baltimore, Md., Pres., Baltimore Stamping and Enameling Co.

Pfeiff, Carl H., 145 Rector St., Perth Amboy, N. J., Supt., General Ceramics Co.

Philips, Wilson A., Trenton, N. J., Pres., Philips-Harper Co.

Phillips, James G., Columbus, Ohio, Chemist, U. S. Bureau of Mines.

Phillips, William L., 1016 San Antonio Ave., Alameda, Cal., N. Clark & Sons.

Pierce, Robert H. H., Box 516, Hazelwood, Pittsburgh, Pa., Chief Chemist, Harbison-Walker Refractories Co.

Pike, Leonard G., Wareham, Dorsetshire, England, Pikes Clay Mines.

Pike, Robert D., 74 New Montgomery St., San Francisco, Cal., Consulting Chemical Engineer.

Pire, Mrs. Ward L., 1745 East 116th Place, Cleveland, Ohio.

Pitcairn, William S., 104 Fifth Ave., New York City.

Pitcock, Lawrence, Crooksville, Ohio, Supt., Crooksville China Co.

Pitt, H. H., Christon Bank, Lesbury, England, Consulting Engineer.

*Plusch, H. A., 6401 N. 11th St., Philadelphia, Pa., Sec. and Factory Mgr., Precision Grinding Wheel Co.

Pohle, Louis, 690 Princeton Ave., Trenton, N. J.

Pohs, F. J., 1097 Interstate Ave., Portland, Ore.

Polen, George A., 1012 Wooster Ave., Canal Dover, Ohio, Gen. Supt., Robinson Clay Products Co.

Polk, Arthur E., 1104 W. Oregon St., Urbana, Ill., Student, University of Illinois.

*Poole, Joshua, East Liverpool, Ohio.

Porter, F. B., 204½ Houston St., Fort Worth, Texas, Pres., Fort Worth Laboratories.

Porter, J. Edward, Box 785, Syracuse, N. Y., Chemical Laboratory, Porter and Clancy.

Post, Albert H., Waterville, Conn., Supt., Gordon Electric Mfg. Co.

*Post, M. P., Commerce, Mo., Supt., Post Brothers.

*Poste, Emerson P., Elyria, Ohio, Chemical Engineers, Elyria Enameled Products Co.

Potter, William A., Richmond, Cal., Factory Manager, Pacific Porcelain Ware Co.

*Potts, Amos, McQueeney, Texas, Seguin Brick and Tile Co.
Powell, C. G., Montezuma, Ind., Mgr., Montezuma Brick Works.
*Powell, William H., 350 Madison Ave., New York City, Pres., Atlantic Terra Cotta Co.
Power, Henry R., Niagara Falls, N. Y., Chemist, Carborundum Co.
Prall, William H., Woodbridge, N. J.
Preston, F. C., 509 Cuyahoga Bldg., Cleveland, Ohio, Vice-Pres. and Sales Mgr., Dover Fire Brick Co.
Primley, Walter S., 133 W. Washington St., Chicago, Ill., Pres., Wisconsin Granite Co.
Prince, Earl S., Downer's Grove, Ill., Ceramic Engineer, Coonley Mfg. Co.
Pritchard, George A., 94 Fulton St., New York City, Second Vice-Pres., Buckman & Pritchard, Inc.
Proodian, E. K., Newtown, Bucks County, Pa.
Pulsifer, H. M. (Address unknown).
*Purdy, Ross C., 1764 N. High St., Columbus, Ohio, General Secretary, American Ceramic Society.
*Purinton, Bernard S., Wellsville, Ohio, United States Pottery Co.
Pyatt, Frank E., (Address unknown).
Quaglino, Louis, 401 Vernon Ave., Long Island City, N. Y., Ceramic Artist, N. Y. Architectural Terra Cotta Co.
Quay, Paul Q., 15620 Euclid Ave., East Cleveland, Ohio.
Rabun, Wiley T., 124 North Santa Fé Ave., Huntington Park, Los Angeles, Cal., Foundryman, Whiting-Mead Commercial Co.
*Radcliffe, B. S., St. Louis, Mo., St. Louis Terra Cotta Co.
Ragland, Nugent A., 1280 West Adams St., Los Angeles, Cal., Research Chemist, Alberhill Coal and Clay Co.
Rahn, Robert C., 5144 Lake St., Chicago, Ill., Ceramic Engineer, Western Electric Co.
Raiff, David A., Coshocton, Ohio, Beach Enameling Co.
*Rainey, Lloyd B., Fallston, Pa., Fallston Fire Clay Co.
Ramsay, Andrew, Mt. Savage, Md., The Andrew Ramsay Co.
*Ramsay, J. D., St. Marys, Pa., Pres. and Gen. Mgr., Elk Fire Brick Co.
Ramsdell, Lewis S., Ann Arbor, Mich., Mineralogical Laboratory, University of Michigan.
Ramsden, C. E., Foley Colour and Chemical Works, Fenton, Stoke-on-Trent, England, C. E. Ramsden & Co.
*Rand, C. C., Nela Park, Cleveland, Ohio, Ceramic Engineer, Experimental Engineering Laboratory, National Lamp Works.
Randall, J. E., Indianapolis, Ind., Junior Editor, "Clayworker."
Randall, T. A., Indianapolis, Ind., Editor, "Clayworker."
*Rankin, G. A., 1800 Virginia Ave. N. W., Washington, D. C., Chemical Warfare Service.

Rapp, John A., 1244 Chicago Ave., Evanston, Ill.

Rathjens, G. W., 240 West George St., St. Paul, Minn.

Rawson, Cummins, Des Moines, Iowa, Iowa Pipe and Tile Co.

*__Rea, William J.__, Buffalo, N. Y., Supt., Buffalo Pottery.

Reagan, F. H., Victor, N. Y., Gen. Mgr., Locke Insulator Co.

Redrow, Walter L., 3533 13th, N. W., Washington, D. C., U. S. Patent Office.

*__Reed, H. M.__, 4032 Cambronne St., N. S., Pittsburgh, Pa.

Reedy, A. J., Battle Creek, Mich., Supt., A-B Stove Co.

Rees, W. J., 102 Ivy Park Road, Ranmoor, Sheffield, England, Lecturer and Head of Research Department in Refractories, University of Sheffield.

Reid, W. H.,(Address unknown).

Reinecker, Hayden P., 145 Industrial Bldg., Washington, D. C., Chemist, U. S. Bureau of Standards.

Remmey, Robert H. Jr., Hedley St. and Delaware River, Philadelphia, Pa., Richard C. Remmey Son Co.

Renkert, Oliver W., Canton, Ohio, Vice-Pres and Gen. Mgr., Metropolitan Paving Brick Co.

Rennieburgh, Cedric L., 625 W. Main St., Zanesville, Ohio.

Rentschler, M. J., Willoughby, Ohio, Gen. Mgr., J. H. R. Products Co.

*__Rhead, Frederick H.__, Zanesville, Ohio, Director, Research Department, American Encaustic Tiling Co.

Rhead, Mrs. Frederick H., Zanesville, Ohio.

Rhead, John, Hotel Columbus, Columbus, Ohio, Mgr., Sanitary Earthenware Specialty Co.

Rhodes, George E., 1609 N. Webster St., Kokomo, Ind., Vice-Pres. and Gen. Mgr., Kokomo Sanitary Pottery Co.

Rhodes, Wm. A., New Cumberland, W. Va., Gen. Mgr., Chelsea China Co.

*__Rice, Bryan A.__, Elyria, Ohio, Elyria Enameled Products Co.

Richard, L. M., 1401 Rialto Blvd., Venice, Cal.

Richardson, E. A., Toledo, Ohio, Libbey Glass Mfg. Co.

*__Richardson, Ernest__, Beaver Falls, Pa., Vice-Pres. and Treas., Ingram-Richardson Mfg. Co.

Richardson, P. B., 210 Otis St., East Cambridge, Mass., Salesman, Harbison-Walker Sales Co.

*__Richardson, W. D.__, 1466 Michigan Ave., Columbus, Ohio, Pres., Ceramic Engineering Co.

Richeux, William A., 343-347 Cortlandt St., Belleville, N. J., Gen. Mgr., "L'Isolantite."

Richman, Sol, Laurel Hill, L. I., N. Y., Factory Mgr., National Enameling and Stamping Co., Inc.

Ricks, Joel O., Roseville, Ohio.

*Riddle, F. H., 121 Gladstone Ave., Detroit Mich., Champion Porcelain
*Ries, Heinrich, Ithaca, N. Y., Professor of Economic Geology, Cornell University.
Riley, R. J., Indianapolis, Ind., Indianapolis Terra Cotta Co.
Risch, Edward J., 4935 Roscoe St., Irving Park Station, Chicago, Ill.
Ritschy, Donald P., Tacony, Philadelphia, Pa., Keystone Lantern Co.
Ritter, J. F., Evansville, Ind., Mgr., Evansville Enameling Co.
Roberts, Frank G., 8th and O'Donnel Sts., Baltimore, Md., Service Engineer, Porcelain Enamel and Mfg. Co.
Roberts, Jane E., Iowa City, Iowa, Librarian, State University of Iowa.
Robertson, Fred H., 809 N. Alvarado St., Los Angeles, Cal., Los Angeles Pressed Brick Co.
Robertson, H. S., Pittsburgh, Pa., Harbison-Walker Refractories Co.
Robertson, Randal K., Cooksville, Ont., Canada, Civil Engineer, Cooksville Shale Brick Co., Ltd.
Robinson, Louis G., Harrison Bldg., Cincinnati, Ohio, Cincinnati Testing Bureau.
Robinson, Maude, 139 Washington Place, New York City, Director, Greenwich House Pottery Dept.
Robison, David V., 104 Woodlawn Ave., Zanesville, Ohio, Ceramic Engineer, Mosaic Tile Co.
Robson, James Thomas, Lord Hall, Ohio State University, Columbus, Ohio, Instructor, Ceramic Engineering.
*Rochow, W. F., Pittsburgh, Pa., Harbison-Walker Refractories Co.
Roddewig, Edward, 411 Harrison St., Davenport, Iowa.
Rodgers, Eben, Alton, Ill., Sec.-Treas., Alton Brick Co.
Rodgers, Louis E., 30 N. LaSalle St., Chicago, Ill., Owner, L. E. Rodgers Engineering Co.
Roehm, Victor Jerome, Newell, W. Va., Asst. Chemist, The Homer-Laughlin China Co.
*Roessler, Franz, 39 High St., Perth Amboy, N. J.
Rogers, Frederick W., Beaver Dam, Wis., Malleable Iron Range Co.
Rogers, Gregory L., Renton, Wash., Denny-Renton Clay and Coal Co.
Rogers, James B., 6231 St. Lawrence Ave., Chicago, Ill., Experimental Engineer.
Rogers, Thomas S., National Silica Co., Chicago, Ill., Special Representative.
Roll, Edward E., 1037 Ansel Rd., Cleveland, Ohio.
*Ross, Donald W., Washington, Pa., Findlay Clay Pot Co.
Rowland, William Martin, 24 Lancaster Rd., Birkdale, England.
Royal, Herbert Franklin, Detroit, Mich., Chemist, Champion Porcelain Co.
Rupp, E. M., Keyport, N. J.

Ruppert, George W., 502 W. 180th St., New York City, Asst. Engineer, The Improved Equipment Co.

Rushmore, Murray, 120 West 8th St., Plainfield, N. J., Moore & Munger.

Rusoff, Samuel, Anderson, Ind., Ceramic Engineer, National Tile Co.

***Russel, John W.**, 522 Chestnut St., Columbia, Pa., Pres., Marietta Hollow Ware and Enameling Co.

Ryan, Charles F., Drawer L, Mount Vernon, Ohio, Sales Engineer, The Chapman-Stein Furnace Co.

Ryan, John F., Woodbridge, N. J., Sec. and Mgr., Mutton Hollow Fire Brick Co.

Ryan, J. J., 810 Sumpter Bldg., Dallas, Texas, Production Mgr. and Sec.-Treas., Fraser Brick Co.

Ryan, Lawrence C., Woodbridge, N. J., Asst. Mgr., Mutton Hollow Fire Brick Co.

Ryan, P. Joseph, Woodbridge, N. J., Pres., Mutton Hollow Fire Brick Co.

Sachs, John E., 203-B South Sixth St., Evansville, Ind., Foreman, Crown Potteries Co.

***Sailly, Paul**, 64 Rue Franklin, Ivry-Port, (Seine), France, Compagnie Generale D'Electro-Ceramique.

Saito, Hachiro, Omuta, Japan, Chief Engineer, Miike Chemical and Dye Works.

***Salisbury, Bert E.**, 1810 W. Genesee St., Syracuse, N. Y., Pres., Onondaga Pottery Co.

***Sanders, John W.**, Moundsville, W. Va., U. S. Stamping Co.

Sanford, Frank W., Evergreen St., Kingston, Mass., Pres. and Gen. Mgr., Sanford Electric Co., South Weymouth, Mass.

Sanner, Harold E., 832 S. English Ave., Springfield, Ill., Poston Brick Co.

Sant, Richard C., East Liverpool, Ohio, Dealer in Feldspar and Clays

***Sant, T. H.**, East Liverpool, Ohio, Pres., The John Sant & Sons Co.

Satoh, Shinzo, Kawasaki, Kanagawaken, Japan, Engineer, Tokyo Electric Co.

Sauereisen, C. Fred, Harvey Ave., East Liverpool, Ohio, Technical Products Co.

Saunders, A. E., 142 Kingsland Ave., Corona, L. I., N. Y.

Saunders, Lewis E., 262 Salisbury St., Worcester, Mass., Mgr., Research and Abrasive Plants, Norton Co.

***Saunders, William E.**, 1401 Arch St., Philadelphia, Pa., United Gas Improvement Co.

Sawyer, John, 142 N. Workman St., Los Angeles, Cal., Kiln Builder.

Saxe, C. W., 54 W. Boylston St., Worcester, Mass., Norton Co.

Saxton, Clement, 35 Bedford St., Strand, London, W. C. 2, England.

Schad, Philip G., 4445 2nd Blvd., Detroit, Mich., Champion Porcelain Co.

Schaeffer, John A., St. Louis, Mo., Vice-Pres., Eagle-Picher Lead Co.

Schermerhorn, Joseph A., 938 Carteret Ave., Trenton, N. J., Trenton Porcelain Co.

Schildmeyer, Vincent DeP., 19 Bank Ave., St. Bernard, Ohio, Supt., The Cincinnati Porcelain Co.

Scholes, S. R., Columbus, Ohio, Chemist, Federal Glass Co.

Schoneich, Philip A., Pittsfield, Mass., General Foreman, Pittsfield Porcelain Works of General Electric Co.

*__Schory, Virgil S.,__ 231 Hudson St., Tiffin, Ohio, Ceramic Engineer, Standard Sanitary Mfg. Co.

Schramm, Edward, 574 Whittier Ave., Syracuse, N. Y., Research Chemist, Onondaga Pottery Co.

Schreiber, George L., Box 265, Santa Monica, Ca.

Schulze, John F. W., Edgewood Arsenal, Edgewood, Md.

*__Schurecht, H. G.,__ 141 Pace Ave., Columbus, Ohio, U. S. Bureau of Mines.

Schurtz, D. D., Lancaster, Ohio, Glass Chemist, Sharp-Schurtz Co.

Schwartzman, Leon A., 5864 De Giverville St., St. Louis, Mo., Chemist, Wallace Pencil Co.

Schwetye, Fred H., St. Louis, Mo., Supt., Christy Plant, Lacledé-Christy Clay Products Co.

Schwier, Carl, 295 E. 4th St., Mansfield, Ohio, Mansfield Vitreous Enameling Co.

Scott, Alexander, Central School of Science and Technology, Stoke-on-Trent, England.

Scott, M. R., 1220 Lake Ave., Rochester, N. Y., Bausch & Lomb Optical Co.

Scott, R. N., Paducah, Ky., Sec.-Treas., Old Hickory Clay and Talc Co.

*__Searle, Alfred B.,__ 440 Glossop Rd., Sheffield, England, Consulting Ceramic Chemist and Engineer.

Seasholtz, J. M., Front and Spruce Sts., Reading, Pa., Owner, Porcelain Enameling Plant.

*__Seaver, Kenneth,__ Pittsburgh, Pa., Harbison-Walker Refractories Co.

*__Sebring, Charles L.,__ Sebring, Ohio, Gen. Mgr., Sebring Pottery.

Sebring, F. H. Jr., Salem, Ohio, Pres., The Salem China Co.

Seelig, Albert F., 2193 Railway Exch. Bldg., St. Louis, Mo.

Segsworth, R. F., 103 Bay St., Toronto, Ont., Canada, Feldspars Ltd.

Sellers, Jas. E., R. F. D. No. 6, Parkersburg, W. Va., Asst. Foreman, General Porcelain Co.

Sewell, Sidney I., 305 W. Perry St., Belvidere, Ill.

***Shanks, Douglas,** Barrhead, near Glasgow, Scotland, Shanks & Co. Ltd., Victorian Pottery.

Shanks, Ronald J., Dalmeny, Barrhead, Scotland, Mgr., J. & N. Craig, Kilmarnock.

Sharp, Donald E., Hamburg, N. Y., Spencer Lens Co.

***Shaw, Joseph B.,** Alfred, N. Y., Assistant Director, New York State School of Clay-Working and Ceramics.

***Shaw, L. I.,** Washington, D. C., U. S. Bureau of Mines.

Shaw, Lucian, West Lafayette, Ohio, Sec., West Lafayette Mfg. Co.

Sheehy, J. F., Newport, Ky., Supt. and Mgr., Alhambra Tile Co.

Shelton, George R., 703 W. Illinois St., Urbana, Ill., Corning Glass Works Fellow, University of Illinois.

Sheppard, Mark, Plymouth Meeting, Pa., E. J. Lavino & Co.

Sherwin, Ralph S., East St. Louis, Ill., Chief Chemist and Chemical Engineer, Aluminum Ore Co.

Sherwood, Robert F., Muncie, Ind., Muncie Clay Products Co.

Shibata, R., 41 Kamiroku, Tokyo, Japan, Professor, Technical High School.

Shively, R. R., Fairmont, W. Va., Chemical Engineer, Monongah Glass Co.

***Shoemaker, George W.,** Brazil, Ind., Clay Products Co.

Short, Frank, Aberdeen Proving Ground, Md.

Shultz, J. Emmet, Zanesville, Ohio, Modeler, American Encaustic Tiling Co.

Sieurin, Emil, Hoganas, Sweden, Engineer.

***Silverman, Alexander,** Pittsburgh, Pa., Head, Department of Chemistry, University of Pittsburgh.

Silvers, James L., Trenton, N. J., Mgr., Trent Tile Co. Inc.

***Simcoe, George,** 64 S. Hermitage Ave., Trenton, N. J., Electric Porcelain and Mfg. Co.

***Sinclair, Herbert,** Trenton, N. J., Gen. Mgr., Star Porcelain Co.

***Singer, Felix,** Carmerstrasse 18, Charlottenburg 2, Germany.

***Singer, L. P.,** Lincoln, Cal., Chemist, Gladding McBean & Co.

Singh, Dogar, c/o Messrs. Sunder Singh and Makhan Singh, Military Contractors, Lahore Cant East, Punjab, India.

Skidmore, G. R. J., Merton House, Whitley Bay, Northumberland, England.

Skinner, Ramsey, 4471 Olive St., St. Louis, Mo., Treas., Reeves & Skinner Machinery Co.

Sladek, George E., Beaver Falls, Pa., Beaver Falls Art Tile Co.

Slater, W. M., 622 F St. N. W., Washington, D. C., Pres., American Rutile Co.

Sloan, Alex, Box 410, Cumberland, Md.

Slobodkin, S. H., 146 Condor St., East Boston, Mass., Boston Pottery Co., Inc.

Smith, A. M., 401 Columbia Bldg., Portland, Ore.

Smith, C. B., 1010 Hancock St., Saginaw, W. S., Mich., Asst. Supt., National Plate Glass Co.

Smith, Charles A., 1150 Oak St., Columbus, Ohio, Student, Ohio State University.

Smith, Harry W., Box 360, Cleveland, Ohio, Roessler & Hasslacher Chemical Co.

Smith, H. P., Jersey City, N. J., Joseph Dixon Crucible Co.

Smith, James M., New Castle, Pa., Treas., Shenango Pottery Co.

Smith, Maurice A., Jeanette, Pa., Vice-Pres. and Gen. Mgr., McKee Glass Co.

Smith, Norman G., Brunswick, Me., Mgr. and Treas., Maine Feldspar Co.

Smith, Perry A., New Brighton, Pa., Sec., A. F. Smith Co.

Smith, Roy G., Fort Worth, Texas, Plant Mgr., Acme Brick Co.

Smith, Wilbur R., 344 N. Pearl St., Bridgeton, N. J.

***Smith, Will L.**, Chester, W. Va., Gen. Mgr., Taylor, Smith & Taylor Co.

Smoot, C. E., 1900 Santa Fé Ave., Los Angeles, Cal., Pres., American Enameling & Stamping Co.

Smyser, Albert E., 239 South Fairmount St., E. E., Pittsburgh, Pa., Engineer of Refractories, Koppers Co.

Snowdon, William C., c/o Mrs. Wild, 259 Spring Vale Rd., Walkley, Sheffield, England.

Solon, G. C., Worcester, England, Managing Director, The Royal Porcelain Works.

***Solon, L. V.**, Magnolia Ave., Tenafly, N. J.

***Solon, Marc**, Trenton, N. J., Gen. Mgr., Mercer Pottery Co.

***Sortwell, H. H.**, 143 Industrial Bldg., Washington, D. C., U. S. Bureau of Standards.

***Sosman, Robert B.**, Washington, D. C., Geophysical Laboratory.

Speirs, Chas. W., London, S. W., England, The Morgan Crucible Co., Battersea Works.

Spier, Harry F., 15 Park Row, New York City, Pres., N. J. Pulverizing Co.

***Springe, Otto**, 371 S. Cherry St., Galesburg, Ill., Ceramic Engineer, Purington Paving Brick Co.

***Sproat, Ira E.**, 196 W. Maryland Ave., Sebring, Ohio, Sebring Pottery Co.

***Spurrier, Harry**, Peru, Ind., Square D Co.

***Staley, Homer F.**, 120 Broadway, New York City, Metal and Thermit Corp.

Stallings, A. G. T., Mexico, Mo., Supt., A. P. Green Fire Brick Co.

Stamm, Charles L., 212 W. 2nd St., Mt. Vernon, N. Y., Ward Leonard Electric Co.

***Stanger, Frederick**, Real Estate Trust Bldg., Philadelphia, Pa., Sales Mgr., Enterprise White Clay Co.

Stangl, J. M., Flemington, N. J., Factory Mgr., Fulper Pottery Co.

***Staudt, August**, Perth Amboy, N. J., Pres., Perth Amboy Tile Works.

Stein, Alan, Bonnybridge, Scotland, Director, J. G. Stein & Co., Ltd.

***Steinhoff, F. L.**, 1906 N. Kedzie Ave., Chicago, Ill., Managing Editor, "Brick and Clay Record."

Stepan, A. C., 589 E. Illinois St., Chicago, Ill., Mgr., Roessler & Hasslacher Chemical Co.

***Stephani, Wm. J.**, Crum Lynne, Pa., Ketcham Terra Cotta Co.

Stern, Newton W., 67 New Montgomery St., San Francisco, Cal., Sec.-Treas., Pacific Porcelain Ware Co.

***Stevens, Douglas F.**, 412 Adams Bldg., Danville, Ill., Supt., Acme Brick Co.

Stevenson, Thomas C., 421 N. Front St., Wheeling, W. Va., Chairman, Mack Mfg. Co.

Stevenson, Wm. G., Oregon, Ill., Sec.-Treas., Ohio Silica Co.

Stewart, Andrew H., Pittsburgh, Pa., Mellon Institute.

Stewart, John G., 530 Union Trust Bldg., Cincinnati, Ohio, Dist. Mgr., Stephens Adamson Mfg. Co.

Stockdale, V. B., 609 W. Meek St., Abingdon, Ill., Supt., Abingdon Sanitary Mfg. Co.

Stone, Charles A., 3226 Potomac Ave., Chicago, Ill.

***Stone, Charles H. Jr.**, 11110 Detroit Ave., Cleveland, Ohio, Research and Industrial Chemist, Kemet Laboratories Co.

Stone, George C., 160 Front St., New York City, N. J. Zinc Co.

Stoneman, William N., Charleroi, Pa., Chemist, Macbeth-Evans Glass Co.

†**Storer, Mrs. Bellamy**, Cincinnati, Ohio, Founder, Rookwood Pottery.

Storey, O. W., Madison, Wis., Metallurgist, C. F. Burgess Laboratories.

***Stout, Wilber**, 291 East Northwood Ave., Columbus, Ohio.

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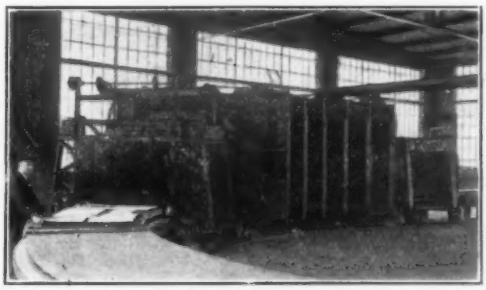

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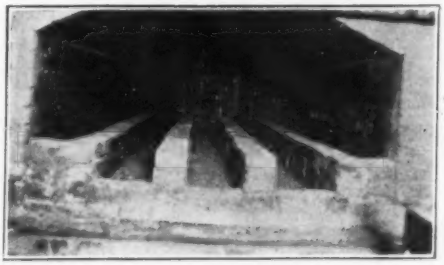

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